# Disturbed LSL Sites had Highest Pb

## Pipe Scale Analysis Results

| | Layer | Al | Ca | Fe | P | Pb | Zn |
|---|---|---|---|---|---|---|---|
| **Pb Service Line Average** | 1 | 16 | 7 | 1.9 | 11 | 14 | 0 |
| | 2 | 12 | 4 | 0.5 | 6 | 39 | 0 |
| | 3 | 4.8 | 1 | 0.4 | 2.1 | 62 | 0 |
| | 4 | 0.4 | 0 | 0.1 | 0.2 | 80 | 0 |

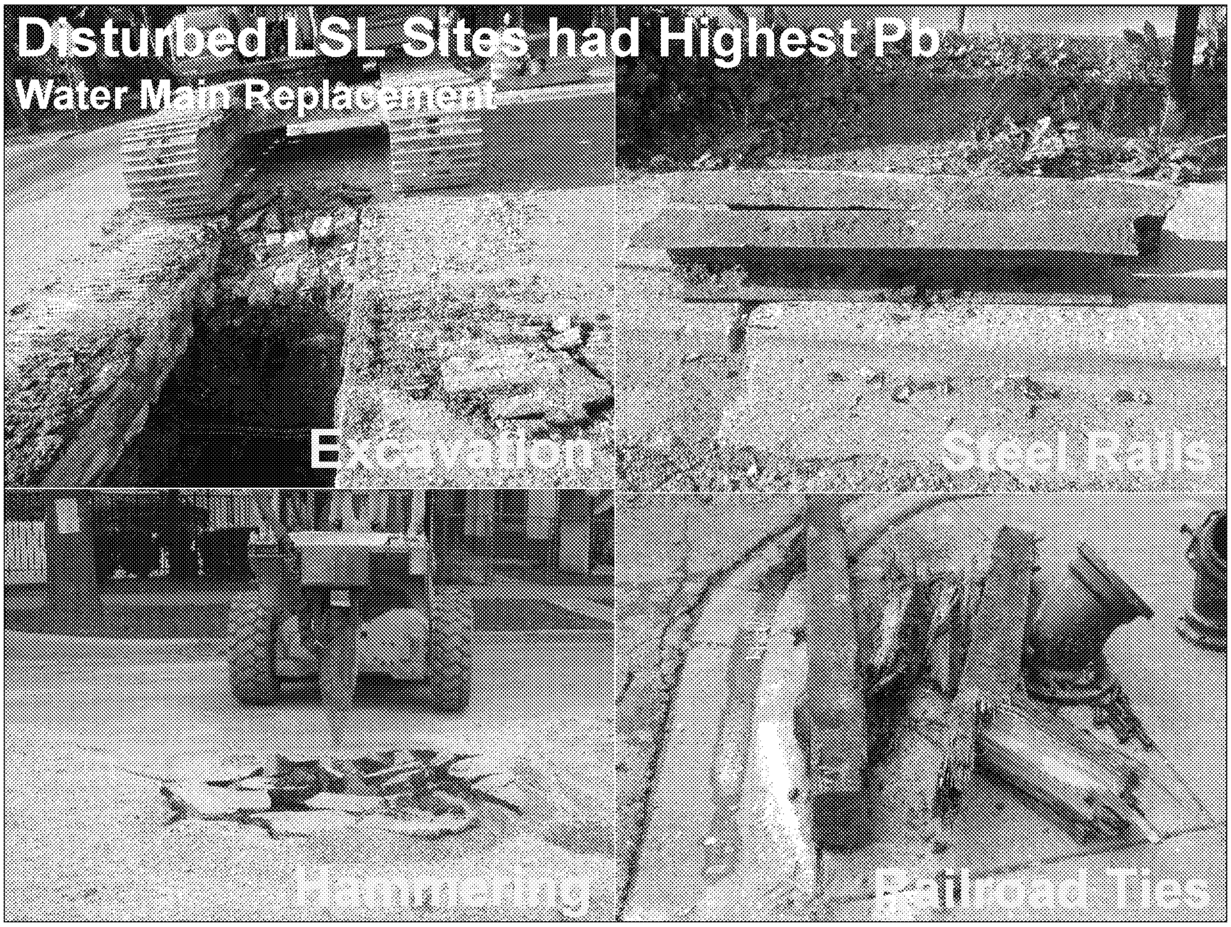
*Elements are expressed in weight %.

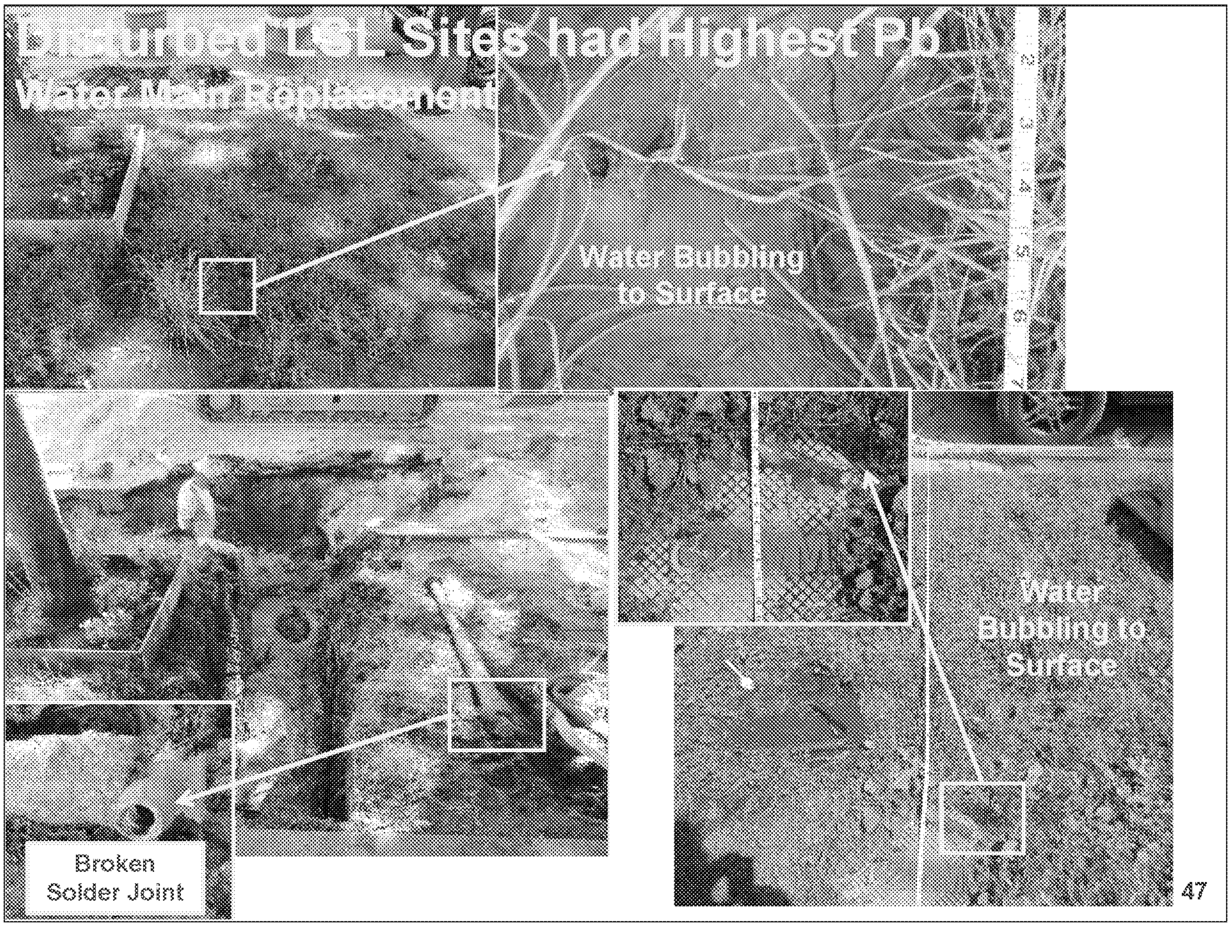
## Conclusions

- No insoluble Pb-phosphate found in any scale layer.
- Layer 1 → blanket-like layer with elevated Al, Ca, and P content.

Inhibition of Pb release here does not follow general theory of insoluble scale. Instead, Pb release inhibited by amorphous diffusion barrier (blanket-like layer).

- **Why?** Composition of the Pb pipe barrier layer may be due to reaction of blended phosphate and Al carry-over from coagulation and natural hardness.
- **How does this increase Pb release risk?** Layer 1 is not well-adhered to pipe wall. Layer 1 easily sloughs off when disturbed. Dislodged scale releases particulate Pb. When Layer 1 is knocked off, exposes underlying layers with higher Pb content.


Disturbed LSL Sites had Highest Pb
Water Main Replacement
Excavation
Steel Rails
Hammering
Railroad Ties


Disturbed LSL Sites had Highest Pb
Water Main Replacement
Water Bubbling to Surface
Broken Solder Joint
Water Bubbling to Surface
47

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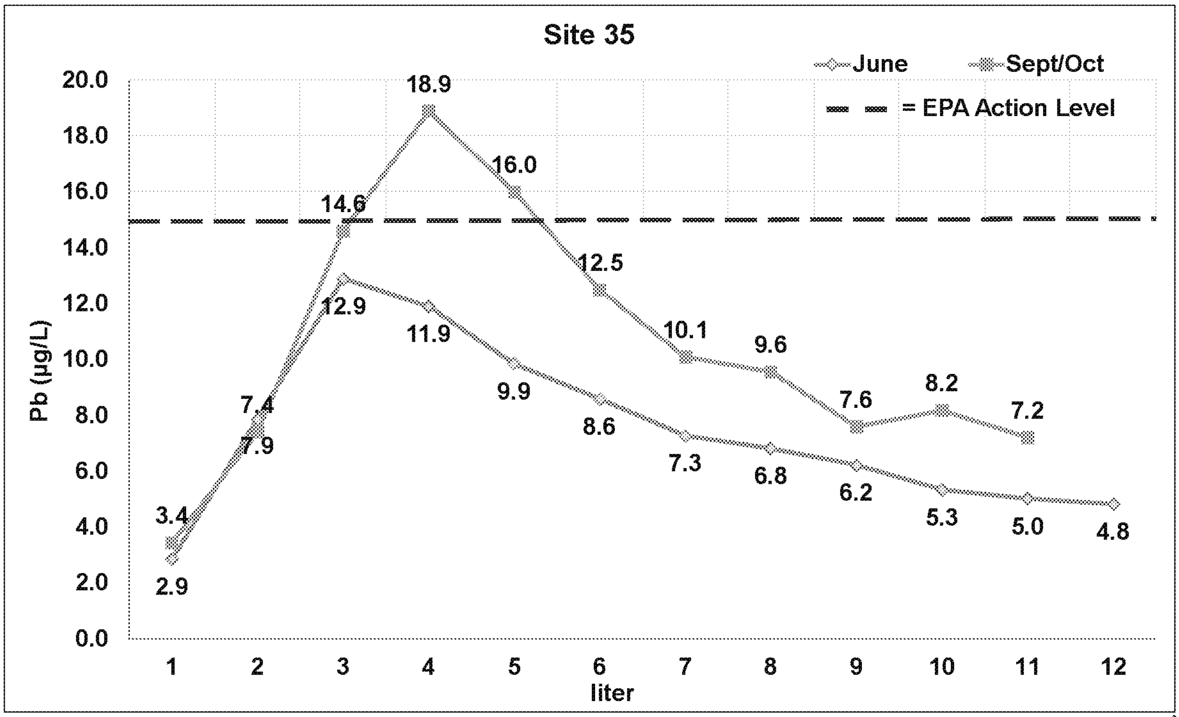
# Study Example: Before & After
## Aug 2011 Meter Install

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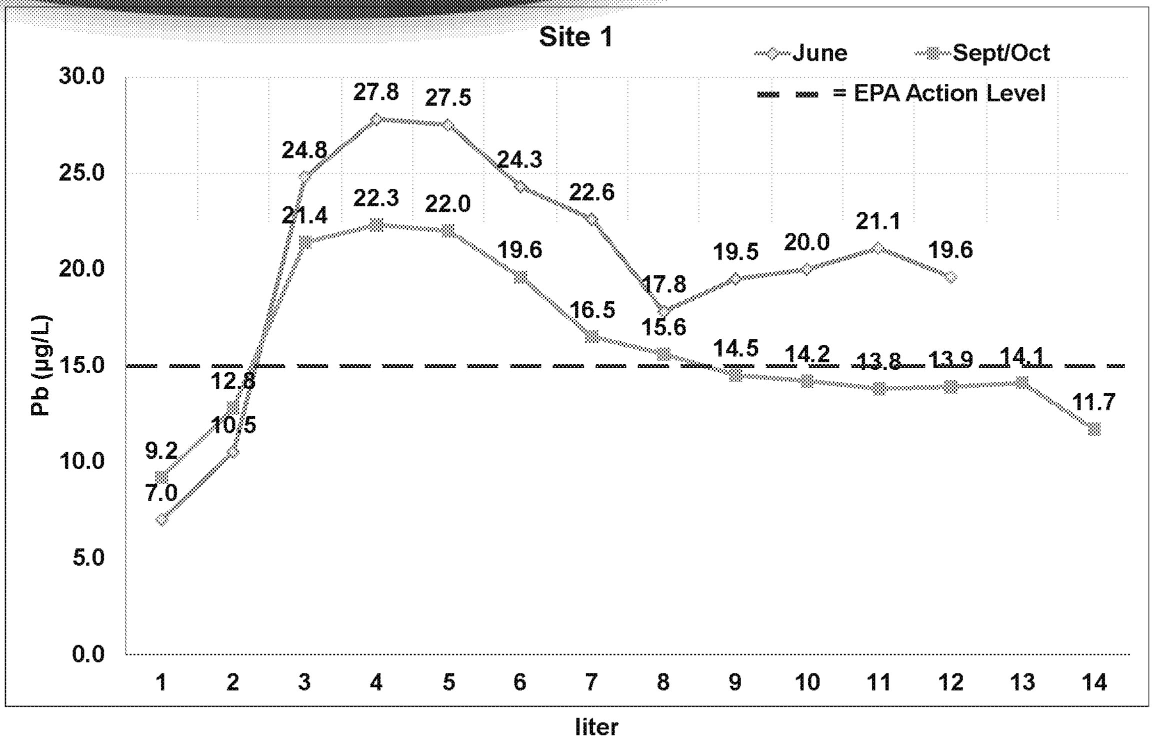
# Findings: Low Water Usage

## May → Higher Pb

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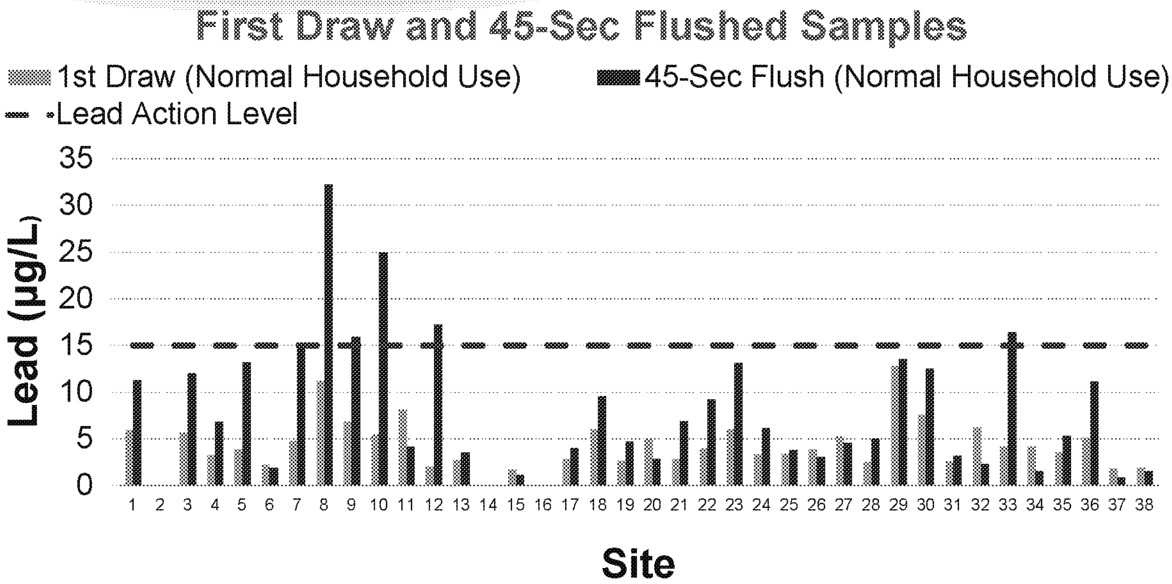
# More Appropriate Flushing Guidance Is Needed

# Flushing Guidance Takes Consumers to Higher Pb




Results → EPA's '30 to 45 second' flushing guidance can take residents with LSLs to **higher** lead.

| Flushed Sample Summary Table (µg/L) | | | | | |
|---|---|---|---|---|---|
| Site | NHU 45sec | PF 45sec | 3min | 5min | 7min |
| 01 | 11.3 | 11.9 | 6.48 | 6.56 | 6.97 |
| 03 | 12.0 | 6.71 | 3.78 | 2.93 | |
| 04 | 6.76 | 2.56 | | | |
| 05 | 13.2 | 14.1 | | | |
| 06 | 1.90 | 2.13 | | | |
| 07 | 15.3 | 24.9 | 5.49 | 5.46 | 5.32 |
| 08 | 32.2 | 28.0 | 8.25 | 5.54 | 5.71 |
| 09 | 15.9 | 17.7 | 14.3 | 7.23 | |
| 10 | 25.0 | 21.6 | 4.95 | 4.30 | 4.09 |
| 11 | 4.13 | 5.30 | 1.75 | 1.69 | |
| 12 | 17.2 | 5.45 | 1.78 | 1.45 | 1.33 |
| 13 | 3.50 | 2.94 | | | |
| 17 | 4.00 | 3.70 | 2.88 | 2.76 | 2.86 |
| 18 | 9.57 | 12.4 | 4.15 | 3.71 | |
| 19 | 4.69 | 8.27 | | | |
| 20 | 2.80 | 2.54 | | | |
| 21 | 6.87 | 13.8 | | | |
| 22 | 9.19 | 7.93 | | | |

Flushing for 3 to 5 minutes significantly reduced lead levels in homes that had the highest lead levels.

| Flushed Sample Summary Table (µg/L) | | | | | |
|---|---|---|---|---|---|
| Site | NHU 45sec | PF 45sec | 3min | 5min | 10min |
| 23 | 13.1 | 11.5 | 5.64 | 4.54 | |
| 24 | 6.10 | 4.98 | 6.38 | 12.4 | |
| 25 | 3.75 | ND | | | |
| 26 | 3.02 | 3.45 | 5.06 | 3.23 | |
| 27 | 4.53 | 3.76 | 15.0 | 14.1 | |
| 28 | 4.99 | 4.70 | 4.82 | 3.26 | |
| 29 | 13.5 | 28.6 | 11.9 | 10.9 | 10.8 |
| 30 | 12.5 | 6.52 | 5.80 | 4.82 | |
| 31 | 3.16 | 12.3 | 3.78 | 3.76 | |
| 32 | 2.29 | 7.82 | | | |
| 33 | 16.4 | 14.0 | 4.40 | 4.06 | |
| 34 | 1.51 | 3.30 | 1.83 | 1.75 | |
| 35 | 5.28 | 10.5 | 5.53 | 4.03 | |
| 36 | 11.1 | 8.76 | 7.19 | 5.29 | |
| 38 | 1.60 | 2.30 | | | |

In most cases, flushing longer than 3 minutes did not appreciably reduce lead levels

There remains a 'baseline' level of lead in the drinking water which varies from site to site.

**Red text indicates levels above the lead action level.**

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# Pre-flushing Ahead of Collecting 1st Draw Samples

# Why Pre-flushing before collecting 1st draw samples resulted in the lowest lead levels.

## First-draw Sampling Variants

A *NHU first-draw sample* involves using the water as residents normally do before the 6 hour stagnation period and then not using water in the household for at least 6 hours until the first-draw sample is collected.

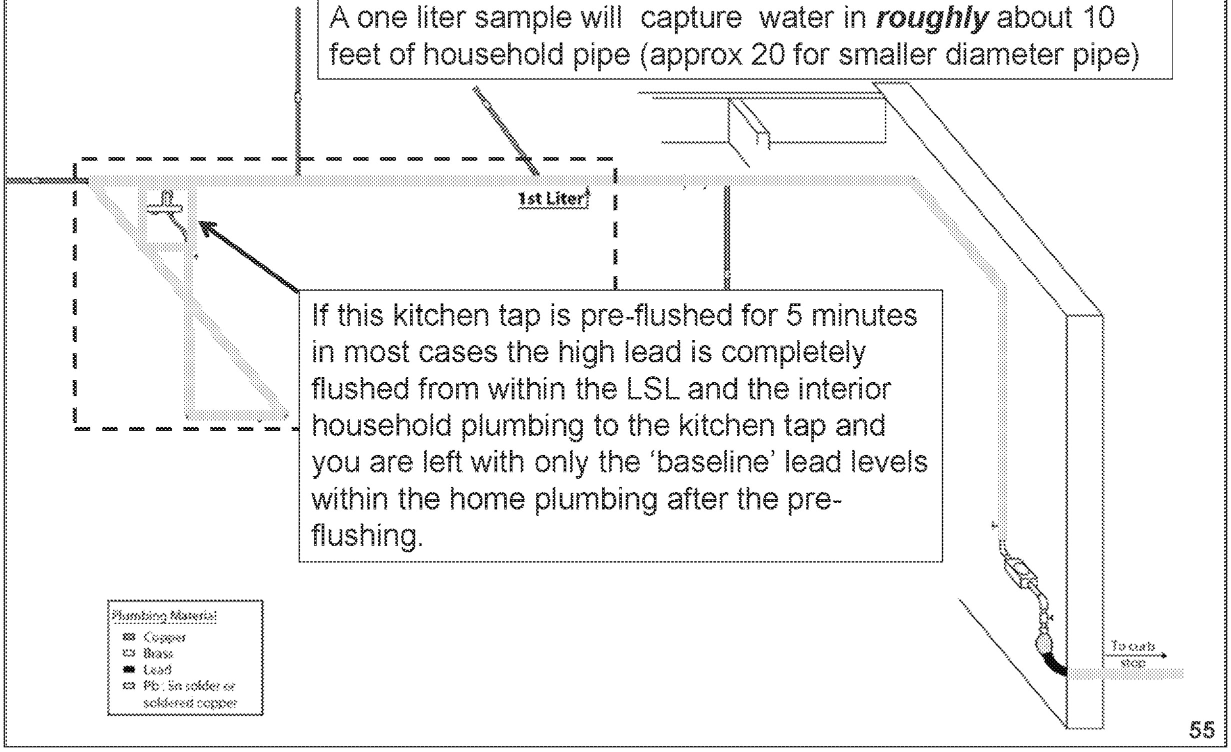
A *pre-flushed (PF) first-draw sample* involves running water for 5 minutes before the 6 hour stagnation period and then not using water in the household for at least 6 hours until the first-draw sample is collected.

A *5-minute flushed sample* involves running the water for 5 minutes and then immediately collecting the sample (no stagnation period).

| | First-Draw | | Flushed |
|---|---|---|---|
| | Sept/Oct 2011 | Sept/Oct 2011 | Sept/Oct 2011 |
| Site | First-Draw NHU | First-Draw PF | 5min |
| Site 1 | 7.4 | 9.2 | 6.6 |
| Site 3 | 10.0 | 8.3 | 2.9 |
| Site 7 | 5.1 | 4.0 | 5.5 |
| Site 8 | 17.5 | 9.2 | 5.5 |
| Site 9 | 15.3 | 8.3 | 7.2 |
| Site 10 | 5.0 | 3.5 | 4.3 |
| Site 11 | 3.5 | 3.0 | 1.7 |
| Site 12 | 2.3 | 5.4 | 1.5 |
| Site 17 | 2.7 | 2.7 | 2.8 |
| Site 18 | 5.8 | 4.8 | 3.7 |
| Site 23 | 9.2 | 7.0 | 4.5 |
| Site 24 | 7.6 | 6.6 | 12.4 |
| Site 26 | 4.5 | 4.9 | 3.2 |
| Site 27 | 8.3 | 12.6 | 14.1 |
| Site 28 | 4.3 | 3.9 | 3.3 |
| Site 29 | 14.9 | 17.6 | 10.9 |
| Site 30 | 8.4 | 7.9 | 4.8 |
| Site 31 | 4.7 | 6.0 | 3.8 |
| Site 33 | 5.6 | 5.5 | 4.1 |
| Site 34 | 2.1 | 1.5 | 1.8 |
| Site 35 | 5.0 | 3.4 | 4.0 |
| Site 36 | 5.9 | 4.6 | 5.3 |
| AVE | 7.0 | 6.4 | 5.2 |

# What a pre-flushed 1st Draw Sample Will Capture

A one liter sample will capture water in ***roughly*** about 10 feet of household pipe (approx 20 for smaller diameter pipe)




If this kitchen tap is pre-flushed for 5 minutes in most cases the high lead is completely flushed from within the LSL and the interior household plumbing to the kitchen tap and you are left with only the 'baseline' lead levels within the home plumbing after the pre-flushing.

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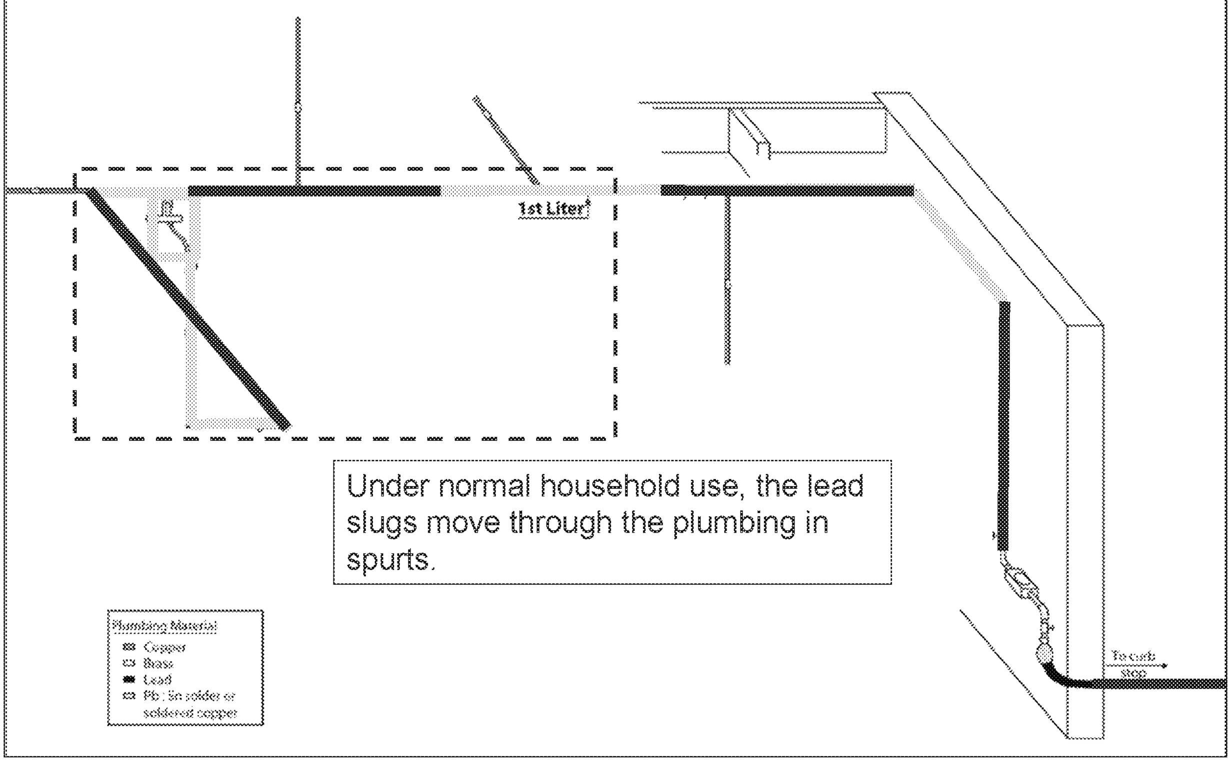
# What a NHU First-Draw Sample Can Capture




Under normal household use, the lead slugs move through the plumbing in spurts.

## Pre-flushed vs. NHU first-draw samples

A one-liter sample will capture the lead in *roughly* ten feet of pipe from the kitchen tap (varies depending on inner pipe diameter and corrosion inside pipes).

Site 8 – Galv. Fe and Cu pipe: LSL is approximately 54 ft from kitchen tap, so a PF 1st draw sample did not catch LSL water, but a NHU sample will sometimes catch it. Therefore, the NHU result can be significantly higher than the PF result.

Site 9 – Galv. Fe pipe: From Meter/LSL is 13.5 ft from kitchen tap so a PF 1st draw sample did not catch the LSL water, but a NHU sample will sometimes catch it. Therefore, the NHU result can be significantly higher than the PF result.

Site 29 – Short Cu pipe: The LSL comes in through the floor right under the kitchen sink so both the PF and the NHU 1st draw sample caught LSL water.

| | First-Draw | | Flushed |
|---|---|---|---|
| | Sept/Oct 2011 | Sept/Oct 2011 | Sept/Oct 2011 |
| Site | First-Draw NHU | First-Draw PF | 5min |
| Site 1 | 7.4 | 9.2 | 6.6 |
| Site 3 | 10.0 | 8.3 | 2.9 |
| Site 7 | 5.1 | 4.0 | 5.5 |
| Site 8 | 17.5 | 9.2 | 5.5 |
| Site 9 | 15.3 | 8.3 | 7.2 |
| Site 10 | 5.0 | 3.5 | 4.3 |
| Site 11 | 3.5 | 3.0 | 1.7 |
| Site 12 | 2.3 | 5.4 | 1.5 |
| Site 17 | 2.7 | 2.7 | 2.8 |
| Site 18 | 5.8 | 4.8 | 3.7 |
| Site 23 | 9.2 | 7.0 | 4.5 |
| Site 24 | 7.6 | 6.6 | 12.4 |
| Site 26 | 4.5 | 4.9 | 3.2 |
| Site 27 | 8.3 | 12.6 | 14.1 |
| Site 28 | 4.3 | 3.9 | 3.3 |
| Site 29 | 14.9 | 17.6 | 10.9 |
| Site 30 | 8.4 | 7.9 | 4.8 |
| Site 31 | 4.7 | 6.0 | 3.8 |
| Site 33 | 5.6 | 5.5 | 4.1 |
| Site 34 | 2.1 | 1.5 | 1.8 |
| Site 35 | 5.0 | 3.4 | 4.0 |
| Site 36 | 5.9 | 4.6 | 5.3 |
| AVE | 7.0 | 6.4 | 5.2 |

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# Lead levels were higher in warmer water temperature months

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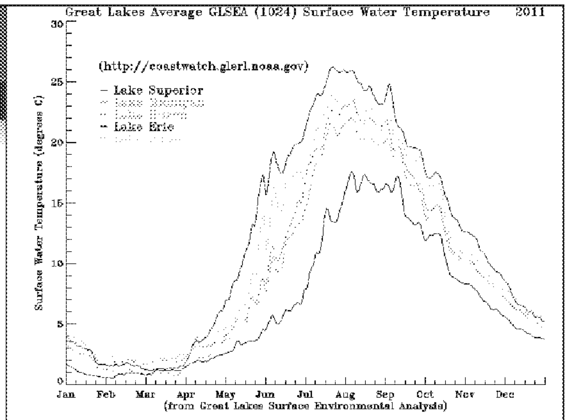
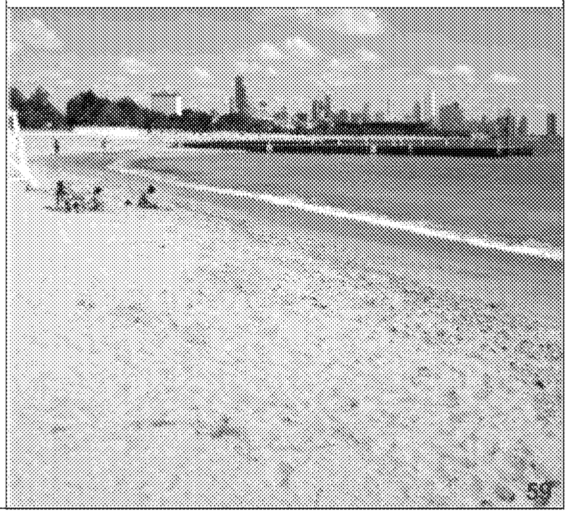
# Seasonal Variability
## Pb Higher in Warmer Months

- The LCR currently requires ‘standard monitoring’ to be conducted during two six-month rounds which each include a broad range of water temperatures
  - January through June
  - July through December
- Sampling conducted in colder water months (Mar/Apr) produced lower Pb levels than samples collected in the warmer water months (Sept/Oct)
  - Overall, 68% and 69% of NHU and PF first-draw samples, respectively, were higher in Sept/Oct than in Mar/Apr.

| First-Draw Mar/Apr vs. Sept/Oct | Normal Household Use | Pre-Flush |
|---|---|---|
| Student's t-Test **P-Value** (two-tailed, paired) | **0.03** | **0.04** |



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# NDWAC Consultation on LCR Revisions

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# NDWAC Consultation on Potential LCR Revisions

- NDWAC White Paper on Potential LCR Revisions:
  - **Sample Site Selection Criteria**
  - **Lead Sampling Protocol**
  - **Public Education for Copper**
  - **Measures to Ensure Optimal Corrosion Control Treatment**
  - **Lead Service Line Replacement**

**NDWAC Website:**
**http://water.epa.gov/drink/ndwac**

# Take Home Messages

[NOT COVERED - RAN OUT OF TIME DURING WEBINAR]

# Take Home Messages

- The current LCR compliance sampling significantly underestimated lead levels
- Care should be taken when performing work to minimize the disturbance of LSLs
  - Provide flushing instructions when LSLs are disturbed (see next slide)
  - Flushing recommendations for homes with LSLs should be updated to avoid increasing consumers' lead exposure.
- Where feasible, removal of LSLs is the best permanent solution
  - AWWA/AMWA: "We support replacement of lead service lines that significantly contribute to high lead levels in the home."
  - LSLs can result in many unintended consequences for other treatment, operational and maintenance activities, as well as compliance complications.

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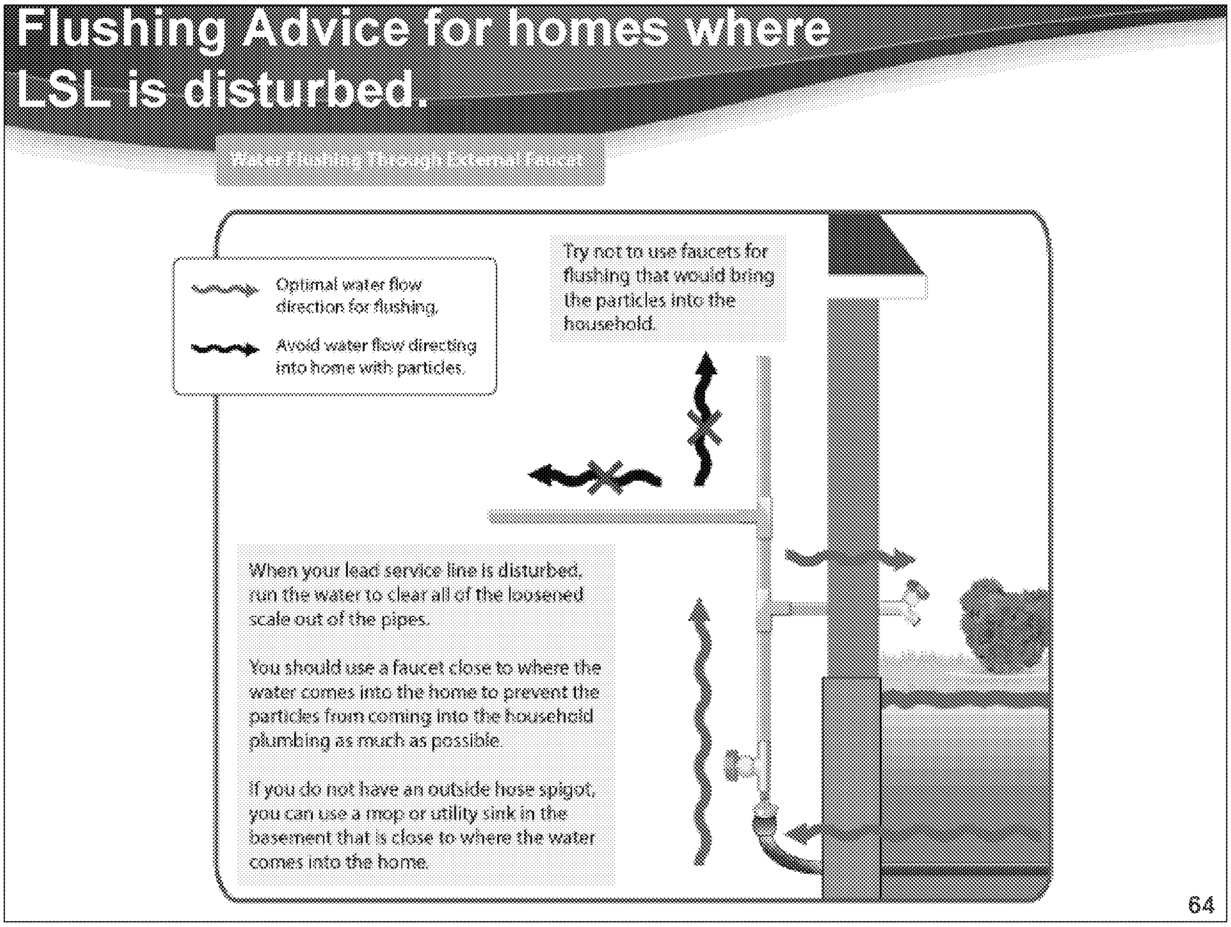


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## Take Home Messages

- PWSs **CANNOT** use alternative site selection criteria or LSL sampling for compliance right now
  - LCR site selection and sampling protocol is prescriptive, with no flexibility to change sampling protocol (static since 1991)
  - PWSs **CAN** use alternative site selection criteria and sampling protocols to help optimize corrosion control.
- **Consult with State!**
  - PWSs can incur violations if LCR sampling requirements are not followed for compliance samples.
- **Provide results to consumers**
  - Although not required by the LCR, residents should be informed of any high lead results from diagnostic monitoring.



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# Identifying Lead-Free Plumbing Certification Marks

- EPA's ORD has developed a brochure for consumers and PWSs:
  - How to Identify Lead-Free Certification Marks for Drinking Water System & Plumbing Materials
  - http://nepis.epa.gov/Adobe/PDF/P100GRDZ.pdf

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## Additional Information

**For more information on Chicago Lead Sampling Study:**
http://www.epa.gov/Region5/water/chicagoserviceline/index.html

- Chicago Lead in Drinking Water Study (download)
- Advice for Residents
- How do I know if I have a LSL
- What do LSLs look like
- Cleaning aerators
- Flushing instructions
- Collecting water samples

**Related Journal Article:**
Del Toral, M. A., Porter, A., & Schock, M. R. (2013). Detection and Evaluation of Lead Release from Service Lines: A Field Study. *Environmental Science and Technology, 47(16),* 9300-9307. doi:10.1021/es4003636


| | | |
|---|---|---|
| Miguel A. Del Toral | deltoral.miguel@epa.gov | 312-886-5253 |
| Michael R. Schock | schock.michael@epa.gov | 513-569-7412 |
| Andrea Porter | porter.andrea@epa.gov | 312-886-4427 |

WDNR/R5 semiannual PWSS call; Monday, March 17, 9-10:30am

## AGENDA with draft discussion notes:

1. **Welcome and Introductions.** (5 minutes)

<u>WDNR</u>: Jill Jonas, Lee Boushon, Mary Ellen Vollbrecht, Steve Elmore
<u>R5:</u> Tom Poy, Rita Bair, Nick Damato, Heather Shoven, Layvette Collymore, Janet Kuefler, Miguel DelToral, Andrea Porter, Michele Palmer and Joe Janczy

2. **Priorities, issues or areas of focus by WDNR for CY14 and beyond**. Jill discussed the recent GAP analysis, reinvestment, and the need for more staff. RTCR will be a priority along with targeted source water protection efforts, including those related to nitrate. There will be a concerted focus to strengthen the 590 standards statewide to better protect ground water sources of drinking water. Since there are many new hires, the program will focus on training and making it a more dedicated process for staff. There is great need to simplify the complexity in our program. The Lead and Copper Rule was used as an example. Full line replacement should be made to be a viable option with expanded options for optimization.

3. **Priorities, issues or areas of focus by EPA for CY14 and beyond.**
    - FY 2014 National Program Managers Guidance webpage-- [ HYPERLINK "http://water.epa.gov/resource_performance/planning/FY-2014-National-Water-Program-Guidance.cfm" ]
    - RTCR and approaches to implementation at small systems, especially non-community water systems.
    - Lead and Copper Rule Long-Term Revisions – need approach to get the lead pipes out.
    - ETT systems and quarterly enforcement updates and referrals - WDNR is doing a good job meeting commitments and working with the Region in providing quarterly updates and referrals.
        - Problem systems, streamlining enforcement sign-off, and assessing administrative penalties for historically violating systems was also discussed.

4. **Issues discussed at ASDWA meeting that are applicable in Wisconsin where further state/regional collaboration may be worth pursuing.** Realism about what can be done based on current/projected resources was discussed. Hesitancy to outwardly acknowledge resource trade-offs continue at the national level. WDNR expressed gratitude to the Region for being open to acknowledge trade-offs in recent years. How to address the threat from *Legionella*, and concern about an expanding PWS inventory was discussed.

5. **Questions or comments on the draft FY13 PWSS grant EOY and measures and indicators summaries.**
Lee questioned the statement under security, and did not commit to implementing the Region's suggestions for operator certification and capacity development program improvement. He mentioned that actions were being taken to improve performance under

both programs, and that those actions would be communicated to Region 5. Joe mentioned that there were few surprises from the 2013 measures and indicators data with the WDNR doing well in meeting its commitments. Region 5 will work to update the language under security.

6. **Nitrate trends in Wisconsin.** Mel explained the slides that were distributed showing a worsening groundwater nitrate trend in most Wisconsin counties and a particularly bad trend line for Rock County. WDNR is optimistic they will have cooperative farmers to work with in one area of the State to measure nitrogen inputs to crops and groundwater to see if nitrate increases to groundwater can be turned around. WDNR will work with DATCP to beef up practices that address N in wellhead protection areas and work with county conservation staff who are implementing the numerical P standards for run-off.

7. **Wells/distribution systems as biological reactors.** Lee discussed recent studies showing the connection between well/distribution system disintegrity, water stagnation, and biolfilms with the presence of microbes, iron, manganese, phosphorus, inorganics (including lead and arsenic) and radionuclides. Based on these studies, reducing scales and biolfilms will likely become an increasing goal for public water systems and needs to be reviewed in the context of the Lead and Copper Rule Long-Term Revisions.

8. **Holistic system preparedness.** Lee discussed a need for a new paradigm in public water system oversight. One in which the problems/inadequacies seen at public water systems are viewed from a collective lens rather than in trying to address each one independently. This approach would use the best professional judgment of the PWS primacy agency inspector to answer a very complex question with a simple yes or no answer—does the public water system have sufficient capacity to provide safe water now and in the future—and would emphasize incremental improvement over sophisticated planning.

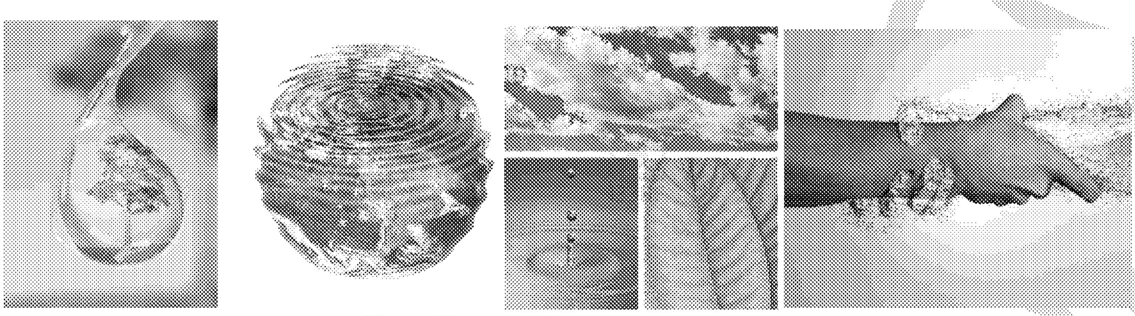
**9. WI RTCR Implementation.** Steve discussed the status of RTCR preparation in Wisconsin. Draft rule language has been developed. WDNR will hold one more meeting with its advisory group. WDNR plans to use flexibility in the rule language to use large volume sampling as a way to move directly to level 2 assessments, so as to allow transient non-community water systems to remain on annual sampling. WDNR will pilot large volume sampling responses after confirmed total coliform-positives very shortly. Six WDNR staffers are being trained to use samplers developed by WSLH's Sharon Long to field test protocols for large volume sample collection. WDNR and Region 5 will continue to work together to adjust the proposal to meet primacy requirements.

# Region 5 PWSS State Directors' Meeting

Tuesday, April 29 and
Wednesday, April 30, 2014

USEPA R5 Office
12th Floor Conference Center
Lake Superior Room

77 W. Jackson Blvd, Chicago



# R5 PWSS Directors' Meeting Agenda

| Tuesday, April 29, 2014, Lake Superior Room<br>Conference call line Personal Phone / Ex. 6 conf code Personal Phone / Ex. 6 | | |
|---|---|---|
| 8:00 am | Early Bird Special: Coffee, Juice, Bagels, Cream Cheese and Networking | All |
| 8:30 am | Setting the Stage for the Day: Welcome, Logistics, Introductions<br><br>Opening remarks | Tom Poy<br><br>Tinka Hyde (confirmed) |
| 9:00 am | USEPA Headquarters' Perspectives<br><br>*Objective: States will receive updated information and responses to questions on office priorities, budget outlook, nutrients, SDWIS-Prime, NCWS Capacity Development, RTCR, and other current topics.* | Michelle Schutz, OGWDW (confirmed) |
| 10:00 am | **Break** | |
| 10:15 am | States Round Robin (15 minutes per state): OH, WI, IL, IN, MI, MN<br>• Issues, changes, areas of focus<br>• What are our next steps?<br><br>*Objective: Understand the status and challenges of State programs, share resources and insights, provide a foundation for future discussions of State priorities and R5 oversight priorities.* | State PWSS Directors |
| 12:00 pm | **Lunch on Your Own** | |
| 1:30 pm | Program Measures<br>• National Measures (5 mins)<br>• Shared goals (10 mins)<br>• Regional high priority data queries, including new rule reporting (10 mins)<br>• Primacy (5 mins)<br>*Objective: Discuss end-of-year (EOY) report status, shared goals status, and high priority query indicators and measures of program performance.* | Tom Poy<br>Rita Bair<br>State PWSS Directors |
| 2:00 pm | Program implementation:<br>• Grants – PWSS/DWSRF<br>• Lab Certification<br>• RTCR implementation—state perspectives and status of state rule adoption, with state discussion of specific NCWS implementation challenges<br>• LCR variances from treatment (utility of allowing PWSs to bypass treatment and go straight to full LSL replacement in cases where phosphorus reductions need to occur in nearby waterbodies | Steve Marquardt,<br>Gerry Bakker & Andy Bielanski;<br>Rita Bair<br>Miguel Del Toral<br>Jill Jonas, WDNR,<br>State PWSS Directors |
| 3:00 pm | **Break** | |
| 3:15 pm | Emerging contaminants:<br>• Harmful Algal Blooms/algal toxins & State activities to reduce occurrence and to monitor near intakes (what monitoring strategies states are using and what are the threshold levels for issuing use advisories; how MN set their level and plans for when USEPA issues advisory numbers)<br>• PFCs | Dave McMillan, IEPA &<br>Mike Baker, OEPA;<br>State PWSS Directors<br>Randy Ellingboe, MDH |
| 4:30 pm | **Adjourn** | |
| 5:30 pm | Group Dinner - ____________<br>Meet in Club Quarters Hotel Lobby (111 W. Adams) at 5:30 PM to walk over to | All |

| | | |
|---|---|---|
| | restaurant. We will have reservations at 6:00 PM. | |

| Wednesday, April 30, 2014, Lake Superior Room<br>Conference call line Conference call line Personal Phone / Ex. 6, conf code Personal Phone / Ex. 6 | | |
|---|---|---|
| 8:00 am | Early Bird Special: Coffee, Juice, Bagels, Cream Cheese, and Networking | All |
| 8:30 am | States discussion of items 3. and 5/6 described below on sanitary surveys, handling line breaks and service disruptions—or cover during round robin? | |
| 9:30 am | Farm Bill/Nutrients<br>• Ways PWS and States can protect drinking water, and assistance that can be provided.<br>• Ways EPA plans to work with partner agencies and internally in water and agriculture programs to assure a focus on drinking water source protection. | Speaker TBD |
| 10:30 am | **Break** | |
| 10:45 am | Climate Change tools demo<br><br>*Objectives: Gain a practical understanding from a PWS demonstrating a tool of how it helped them.* | Seeking pws contact from david travers/curt Baranowski, *Water Security Division, HQ* |
| 11:30 am | Legionella multi-agency workgroup, status of draft agreement, and Ohio's approach including discussion of 4. and 6 below. | Mike Baker, OEPA<br>Randy Ellingboe, MDH |
| 12:00 noon | Data working lunch?? Lab to state data, CDVRT, SDWIS-Prime?? | Pat Carroll, IDEM--For lab to state? |
| 1:15 pm | Small Systems<br>• NCWS WG update (MDH);<br>• (OH capability assurance framework?? (OEPA)<br>• MI efforts to train LHDs (MDEQ)<br>• States input on new capacity development approaches for small systems | Randy Ellingboe, MDH<br>Mike Baker, OEPA<br>Liane Shekter Smith, MDEQ<br>State PWSS Directors |
| 1:45 pm | Review follow-up items, discuss date for next year's annual meeting, recommended changes to meeting format, etc. | Tom Poy |
| 2:00 pm | **End of meeting** | |

Other potential topics

1. Enforcement
2. Chloride
3. san survey resources & training--how do states track and enforce significant deficiencies and other requirements from sanitary surveys? Also, what type of auditing or other oversight do states have in place to verify the quality of surveys?
4. How are states regulating facilities treating for Legionella that would otherwise be exempt? Regulated as PWS? Monitoring and operator requirements? Applicability of MCLs and other requirements? Ohio can share what we are proposing and would like to hear how other states are approaching this issue.
5. How do states handle significant line breaks and other significant disruptions in the distribution? How is a depressurization defined? What are the policies are for sampling (CL residuals, bac-t) and issuing use advisories?
6. Related to topics 4 and 5 above is the requirement for chlorine residuals to manage risks in the distribution. Darren Lytle brought up distribution demand as a topic of research. *Should we contact Darren re: a status update?*

Attachment B

## SDWIS/FED REQUIREMENTS FOR MCL VIOLATIONS END DATES

| Rule | Extended end date allowed? Yes/No | Requirement |
|---|---|---|
| CR | N | TCR MCL violation end dates must be 1 to 12 months from the compliance period begin date. |
| hem - IOC | Y | IOC MCL violation end dates must be 1 to 120 months from the compliance perioc begin date. |
| hem - VOC | Y | VOC MCL violation end dates must be 1 to 120 months from the compliance period begin date. |
| hem - SOC | Y | SOC MCL violation end dates must be 1 to 120 months from the compliance perio begin date. |
| hem - Nitrate/Nitrite | Y | Nitrate/Nitrite MCL violation end dates must be 1 to 120 months from the compliance period begin date. |
| hem - Arsenic | Y | Arsenic MCL violation end dates must be 1 to 120 months from the compliance period begin date. |
| hem - Rads | Y | Rad MCL violation end dates must be 1 to 120 months from the compliance period begin date. |
| CR/LCRMR | -- | NA, no MCL violations just TT |
| WTR | -- | NA, no MCL violations just TT |
| ESWTR | -- | NA, no MCL violations just TT |
| PBR - Stage 1 xcluding TTHMs | N | Includes Chlorite (1009), Bromate (1011), HAA5 (2456). Chlorite has a one mont duration and Bromate and HAA5 has a three month duration. |
| PBR - Stage 1 TTHMs | Y | No restrictions cited in FedRep 2.0 requirements document. |
| N | -- | NA |
| ilter Backwash | -- | NA, no MCL violations just TT |

## Khym, John

**From:** Stark, Alan
**Sent:** Wednesday, February 20, 2013 8:11 AM
**To:** Putz, Andrea; Khym, John; Riordan, Denis
**Subject:** Service Line Size and Composition

USEPA has asked if we have a document or a plumbing code that lists the different sizes of services and pipe composition required in Chicago. They are looking for information prior to the 1986 change from lead to copper; as well as today's requirements

Alan Stark
Water Quality Manager
Department of Water Management
Jardine Water Purification Plant
Chicago, Illinois 60611
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The Committee on Buildings submitted the following report:

CHICAGO, August 28, 1986.

*To the President and Members of the City Council:*

Your Committee on Buildings having had under consideration a proposed ordinance amending Chapters 82 and 83 of the Municipal Code of Chicago to prohibit the use of lead water supply pipe, begs leave to recommend that Your Honorable Body *Pass* the substitute ordinance which is transmitted herewith.

This recommendation was concurred in by the members present of the committee with no dissenting votes.

Respectfully,
(Signed) FRED B. ROTI,
*Chairman.*

On motion Alderman Roti, the said proposed substitute ordinance transmitted with the foregoing committee report was *Passed* by yeas and nays as follows:

*Yeas* -- Aldermen Roti, Rush, Tillman, Evans, Bloom, Sawyer, Beavers, Humes, Hutchinson, Huels, Majerczyk, Madrzyk, Burke, Carter, Langford, Streeter, Kellam, Sheahan, Kelley, Sherman, Garcia, Krystyniak, Henry, Soliz, Gutierrez, W. Davis, Smith, D. Davis, Hagopian, Santiago, Gabinski, Kotlarz, Banks, Giles, Cullerton, Laurino, O'Connor, Pucinski, Natarus, Oberman, Hansen, McLaughlin, Orbach, Volini, Orr, Stone -- 46.

*Nays* -- None.

Alderman Natarus moved to reconsider the foregoing vote. The motion was lost.

Alderman Frost was excused from voting under the provisions of Rule 14 of the Council's Rules of Order.

The following is said ordinance as passed:

*Be It Ordained by the City Council of the City of Chicago:*

SECTION 1. Chapter 82 of the Municipal Code of the City of Chicago be and hereby is amended by repealing section 82-25.

SECTION 2. Section 82-29 of the Municipal Code of Chicago is hereby amended by deleting the language bracketed and adding the language in italics as follows:

82-29. All copper tubing shall conform to A.S.T.M. "Standard Specifications for Copper Water Tube" (Serial Designation [B88-74] *B88-83)*, and shall be Type K, L, or M.

SECTION 3. Section 82-32 of the Municipal Code of Chicago is hereby amended by deleting the language contained in brackets as follows:

82-32. All lead pipe shall be of the best quality of drawn pipe of not less weight per linear foot than shown below.

Lead Soil, Waste, Vent or Flush Pipes, Including Bends and Traps, Extra Light

| Internal diameter inches | Weights per foot lbs. | ozs. |
|---|---|---|
| 1 | 2 | ... |
| 1-1/4 | 2 | 8 |
| 1-1/2 | 3 | 8 |
| 2 | 4 | 12 |
| 3 | 6 | ... |
| 4 | 7 | 14 |

[Lead Water Supply Pipe]

[

| Internal diameter inches | Weights per foot lbs. | ozs. |
|---|---|---|
| 1/2 | 1 | 8 |
| 5/8 | 2 | 8 |
| 3/4 | 3 | ... |
| 1 | 4 | ... |
| 1-1/2 | 8 | ... |
| 2 | 13 | 12 |

]

SECTION 4. Section 82-42 of the Municipal Code of Chicago is hereby amended by deleting the language contained in brackets and adding the language in italics as follows:

82-42. Soldered fittings for copper tubing shall be of cast [brass] *copper alloy* or of wrought copper *and copper alloy* and shall be capable of withstanding a pressure test of not less than two hundred fifty pounds per square inch.

SECTION 5. Section 82-136 of the Municipal Code of Chicago is hereby amended by deleting the language contained in brackets and adding the language in italics as follows:

82-136. Every joint in a lead *drainage system* pipe or between a lead *drainage system* pipe and a brass or copper *tube or* pipe, ferrule, soldering nipple, [bushing,] or trap, shall be a burned or full-wiped joint with an exposed surface of the solder extending to each side from the end of the pipe not less than three-fourths of an inch and with a minimum thickness at the center of not less than three-eighths of an inch. *Joints on drainage systems between brass tubing and a brass bushing shall be soldered or a wiped joint.*

SECTION 6. Section 83-22 of the Municipal Code of Chicago is hereby amended by deleting the language contained in brackets and adding the language in italics as follows:

83-22. The service pipe is the pipe which conveys the water from the mains of the Chicago water works system to the building, structure, or premises served. Each service pipe shall be of sufficient size to permit the continuous and ample flow of water to supply adequately all floors at any given time. No service pipe of [an internal diameter] *a standard pipe size* less than one (1) inch shall be installed in any public way or other public place of the City, nor connected to the mains of the Chicago water works system.

Service pipes shall be sized according to the formula prescribed in Chapter 83-51 of this code, plus any additional requirements for fire protection purposes. Each service pipe shall include a meter spreader connection of like size and of sufficient length to accommodate a full size meter.

SECTION 7. Section 83-23 of the Municipal Code of Chicago is hereby repealed and a new Section 83-23 is hereby enacted to read in italics as follows:

*83-23. All new and replaced service pipes, installed after this section becomes effective, of one (1) inch standard pipe size, one and one-half (1-1/2) and two (2) inch standard pipe size shall be seamless type K annealed (soft) copper water tube conforming to the requirements of A.S.T.M. Standard Specifications B88-83.*

SECTION 8. Section 83-24 of the Municipal Code of Chicago is hereby repealed and a new Section 83-24 is hereby enacted to read in italics as follows:

*83-24. No newly installed water services pipe in a water service connected to a new building, structure, or premises shall be connected to existing water service pipes of materials other than that authorized in Section 83-23 and 83-25 of the Municipal Code.*

*All repairs to existing service pipes and joints, or connections between existing and replacement service pipes, shall be made using fittings that are adaptable to the service* *pipe material being connected and that have been approved by the Department of Water and Electrical Inspection Section of the Department of Inspectional Services. No filler material or flux with a lead content greater than 0.20% shall be used in the repair or installation of any service pipe two (2) inches or smaller.*

*Except for joints between new copper water tube service pipe and existing service pipe of another material, all joints to new service pipes two (2) inches standard pipe size or smaller shall be made using approved flared fittings secured in the tightened position by a means approved by the Department of Water, or by brazing with approved solder-joint pressure fittings. The number of joints on new services shall be kept to a minimum. Joints shall be made only at the corporation stop, stop cock, and value (meter) settings, unless the distance between them exceeds the length of a standard coil or copper water tube of the diameter used. For the purposes of this section, the length of a standard coil of copper water tube shall be one hundred (100) feet for one (1) inch pipe, sixty (60) feet for one and one-half (1-1/2) inch pipe and forty (40) feet for two (2) inch pipe.*

*Flared copper water tube joints shall be made by the appropriate use of cast bronze fittings conforming to A.N.S.I. specification B16.26-83 and approved for flared copper water tube. Flared ends of copper water tube shall only be made with a flaring tool designed specifically for that purpose.*

*Brazed copper water tube service pipe joints shall be made by the appropriate use of Cast Copper Alloy Solder -- Joint Pressure Fittings conforming to A.N.S.I. specification B16.18-78 or Wrought Copper and Copper Alloy Solder Joint Pressure Fittings conforming to A.N.S.I. Specification B16.22-80. The filler material shall be Silver Brazing Alloy. Filler materials and fluxes with lead content greater than 0.20% are prohibited. Filler materials containing Cadmium shall be used with adequate ventilation only.*

SECTION 9. Section 83-28 of the Municipal Code of Chicago is hereby amended by deleting the language in brackets and adding the language in italics as follows:

83-28. No [lead] *copper water tube* service pipe shall be connected to the mains of the Chicago water works system unless such service pipe is of sufficient length to permit the construction of a non-rigid swing section at its connection to such main. Such swing section shall be constructed in such manner which may be caused by any shock, strain, or vibration to which said service pipe or main may be subjected, and each such swing shall move on an axis composed of the tap coupling and the threaded and screwed joint at the water main and shall conform to the rules and regulations of the Department of Water for such construction.

SECTION 10. Section 83-54 of the Municipal Code of Chicago is hereby repealed and a new Section 83-54 is enacted to read in italics as follows:

*83-54. All new and replaced water supply pipe and fittings installed or replaced after the effective date of this section shall be of materials specified in Table 83-54, subject to the restrictions indicated in Column B of the Table. Water supply pipe and fittings shall conform to the Standards cited in Table 83-54. When the surface of the ground is exposed* *to the weather, all water supply pipes shall be installed at a depth of not less than five (5) feet below the surface of the ground.*

*Table 83-54*

| Column A<br><br>Pipe, tubing and fittings | Column B<br><br>for restricted use see foot notes as indicated | ANSE | Standard<br><br>ASTM | AWWA |
|---|---|---|---|---|
| Black and Hot-dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses. Galvanized Only | A,F | | A-120-32 | |
| Steel Pipe Welded or Seamless (for coiling) Black or Galvanized Galvanized Only | A,F | | A-53-80 | |
| Cast Iron (Gray) Pipe | C | A21.12-71<br>A21.6-80<br>A21.3-75<br>A21.1-67 | | C-112-71<br>C-106-80<br>C-108-75<br>C-101-67 |
| Ductile Iron Pipe | C | A21.51-76 | | C-151-76 |
| Glass Pipe (see 82-21.1 of this code) | A,B | | | |
| Seamless Red Brass Pipe, Standard Sizes | A | | B-43-80 | |
| Seamless Copper Pipe Standard Sizes | A | | B-42-83 | |
| Seamless Copper Water Tube, Type | A,D,E | | B-88-83 | |

| | | | |
|---|---|---|---|
| *K. L, or M* | | | |
| *Type K Seamless Copper Water Tube* | *A,B,D* | | *B-88-83* |
| *Galvanized Malleable Iron Threaded Fittings Classes 150 and 300* | *A* | *B16.3-77* | |
| *Galvanized Cast Iron Threaded Fittings Classes 125 and 250* | *A* | *A16.4-77* | |
| *Galvanized Cast Iron Flanged Fittings Classes 125 and 250* | *A* | *B16.1-75* | |
| *Ductile Iron or Grey Cast Iron Fittings* | *C* | *A21.10-82* | |
| *Cast Bronze Threaded Fittings Classes 125 and 250* | *A* | *B16.15-78* | |
| *Cast Copper Alloy Solder-Joint Pressure Fittings* | *A,B,D* | *B16.18-78* | |
| *Wrought Copper and Copper Alloy Solder Joint Fittings* | *A,B,D* | *B16.22-80* | |
| *Cast Copper Alloy Fittings for Flared Copper Tubes* | | *E* | *B16.26-83* |
| *Bronze Flanges and Flanged Fittings Classes 150 and 300* | | *A* | *B16.24-79* |

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*Footnotes*

A. *Water supply above ground*

B. *Water Supply underground*

C. *Water supply above ground and underground. All cast-iron and ductile water supply pipe and special castings shall have an outside bituminous coating of either coal tar or asphalt base and a cement mortar lining conforming to ANSI A21.4-80 (AWWA C104-80). Joints for cast-iron and ductile iron water supply pipes may be of the mechanical joint type of push-on type conforming to ANSI A21.11-80 (AWWA C111-80) specification or lead and jute gasket caulked type. Each lead and jute gasket caulked joint shall be firmly packed not more than one-fourth (1/4) of its depth with hand picked untreated sterilized jute, flush filled with poured molten pure lead and firmly caulked. Joints for above ground cast-iron or ductile iron water supply pipes may also be of the flanged or grooved type, with the groove not cut deeper than the average effective part of a thread of the same size pipe.*

D. *The filler material for copper tubing sweat fittings above ground shall be 95/5 Tin-Antimony Solder or Silver Brazing Alloys. The filler material for copper tubing sweat fittings underground shall be Silver Brazing alloys. Fillers containing cadmium shall be used with adequate ventilation. The use of filler materials or fluxes with lead content greater than 0.20% is prohibited. The number of joints shall be kept to a minimum in keeping with good plumbing practices.*

E. *Flared copper or compression fittings shall be in a readily accessible location and shall be used with annealed (soft) copper tube. Compression fittings shall not be larger than 1/2 inches and limited to connecting fixtures. Readily accessible means direct access without the necessity of removing or moving any panel, door or similar obstruction. The number of joints shall be kept to a minimum in keeping with good plumbing practices.*

F. *Shall meet the weight requirements of standard weight pipe or heavier.*

SECTION 11. Chapter 83 of the Municipal Code of the City of Chicago be and hereby is amended by repealing section 83.60.

SECTION 12. This ordinance shall be in full force and effect six months after passage and publication. Installation complying with the revised provisions may be made prior to the effective date of this ordinance with permission from, and subject to special conditions of, the Department of Water.

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*Action Deferred* -- MUNICIPAL CODE AMENDED BY ADDING NEW SECTION 193.1 ENTITLED "RESIDENTIAL LANDLORD AND TENANT ORDINANCE."

**18-29-605.4 Water service pipe.**

Water service pipe shall conform to NSF 61 and to one of the standards listed in Table 18-29-605.4. All water service pipe or tubing, installed underground and outside of the structure, shall have a minimum working pressure rating of 160 psi (1100 kPa) at 73.45°F (23.03°C). Where the water pressure exceeds 160 psi (1100 kPa), piping material shall have a minimum rated working pressure equal to the highest available pressure. All ductile iron water pipe shall be cement mortar lined in accordance with AWWA C104.

Table 18-29-605.4
Water Service Pipe

| **Material** | Standard |
|---|---|
| Copper or copper-alloy tubing (Type K) | ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 447 |
| Ductile iron water pipe | AWWA C151; AWWA C115 |

Pipe and pipe fittings (including valves and faucets) utilized in the water supply system shall have a maximum of 8 percent lead content.

**18-29-605.4.1 Materials for supply pipes and fittings.**

All new and replaced water supply pipes and fittings shall be of materials specified in Tables 18-29-605.4, 18-29-605.5 and 18-29-605.6, subject to the restrictions indicated in Column B of the table. Water supply pipe and fittings shall conform to the standards cited in Tables 18-29-605.4, 18-29-605.5 and 18-29-605.6. All pipe and fittings exceeding 8 percent lead content are prohibited in the installation, repair or replacement of water supply pipes.

**18-29-605.5 Water distribution pipe.**

Water distribution pipe shall conform to NSF 61 and shall conform to one of the standards listed in Table 18-29-605.5. All hot water distribution pipe and tubing shall have a minimum pressure rating of 100 psi (690 kPa) at 1805°F (825°C).

Table 18-29-605.5
Water Distribution Pipe

| **Material** | Standard |
|---|---|
| Brass pipe | ASTM B 43 |
| Chlorinated Polyvinyl Chloride (CPVC) plastic | ASTM D 2846; ASTM F 441; ASTM F 442; |

| | |
|---|---|
| pipe and tubing a | CSA B 137.6 |
| Polypropylene (PP) plastic pipe and tubing a | ASTM F 1412 |
| PVDF plastic pipe and tubing a | ASTM F 1412 |
| Copper or copper-alloy pipe | ASTM B 42; ASTM B 302 |
| Copper or copper-alloy tubing (Type K, L, or M) | ASTM B 74; ASTM B 88; ASTM B 251; ASTM B 447 |
| Galvanized steel pipe | ASTM A 53 |

a For secondary water used in process applications only.

**18-29-605.6 Fittings.**

Pipe fittings shall be approved for installation with the piping material installed and shall conform to the respective pipe standards or one of the standards listed in Table 18-29-605.6. All pipe fittings utilized in water supply systems shall also conform to NSF 61. The fittings shall not have ledges, shoulders or reductions capable of retarding or obstructing flow in the piping. Ductile and gray iron pipe fittings shall be cement mortar lined in accordance with AWWA C104.

Table 18-29-605.6
Pipe Fittings

| **Material** | Standard |
|---|---|
| Cast iron | ASME B 16.4; ASME B 16.12 |
| Polypropylene (PP) plastic pipe and tubing a | ASTM F 1412 |
| PVDF plastic pipe and tubing a | ASTM F 1412 |
| Chlorinated polyvinyl chloride (CPVC) plastic a | ASTM F 437; ASTM F 438; ASTM F 439 |
| Copper or copper alloy | ASME B 16.15; ASME B 16.18; ASME B 16.22; ASME B 16.23; ASME B 16.26; ASME B 16.29; ASME B 16.32 |

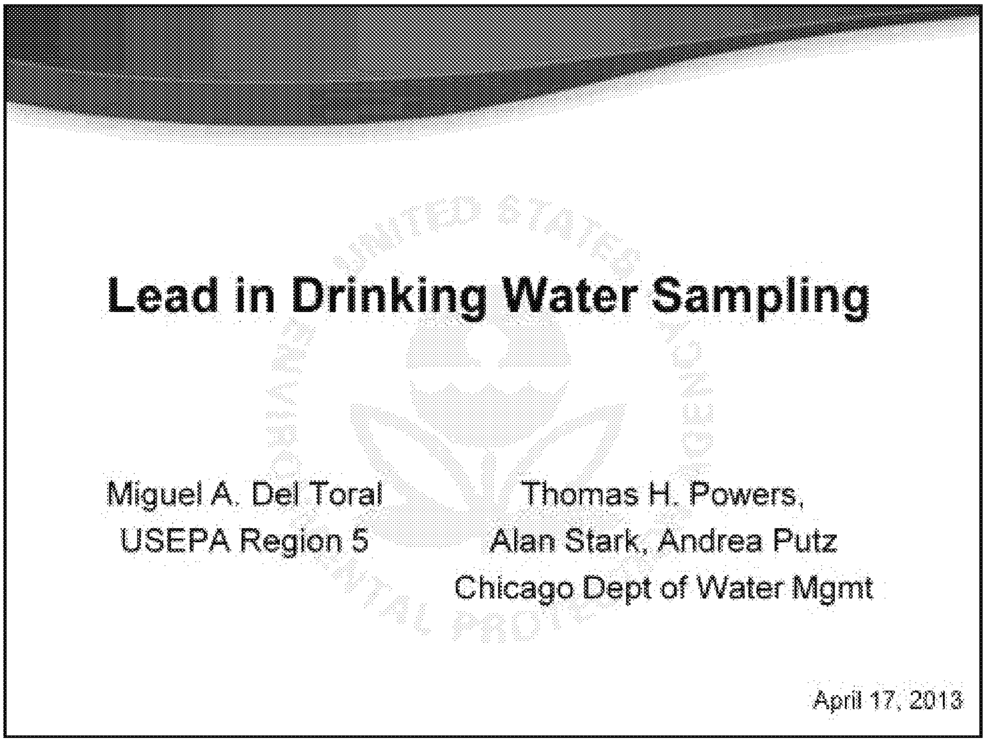
| | |
|---|---|
| Gray iron and ductile iron | AWWA C 110; AWWA C 153 |
| Malleable iron | ASME B 16.3 |
| Steel | ASME B 16.9; ASME B 16.11; ASME B 16.28 |

a For secondary water used in process applications only.

**18-29-605.7 Valves.**

**18-29-603.1 Size of water service pipe.**

The service pipe is the pipe which conveys the water from the mains of the Chicago Waterworks System to the building, structure, or premises served. Each service pipe shall be of sufficient size to permit the continuous and ample flow of water to supply adequately all floors at any given time. No service pipe of a nominal pipe size less than 1 inch (25 mm) shall be installed in any public way or other public place of the city, nor connected to the mains of the Chicago Waterworks System.


Lead in Drinking Water Sampling
Miguel A. Del Toral
USEPA Region 5
Thomas H. Powers,
Alan Stark, Andrea Putz
Chicago Dept of Water Mgmt
April 17, 2013

## Outline

- Purpose of Study
- Partnership with Chicago
- Overview of Study
- Study Findings
- Preparing for Study Publication
- Service Line Particulate
- Additional Chicago Activities Related to Lead

## Purpose of Study

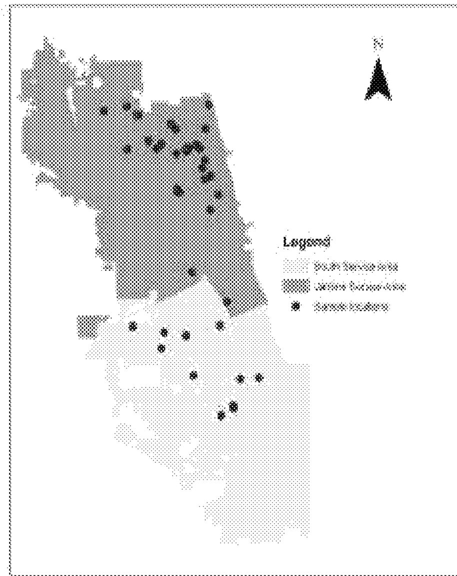
- LCR sampling has not changed since 1991
  - Different first-draw protocols used by public water systems
  - Leaded solder was banned effective in 1988
- Additional information available research and unintended consequences of system treatment changes
- EPA is proposing long-term revisions to the LCR
  - Include a review of current sampling requirements

## Partnership with CDWM

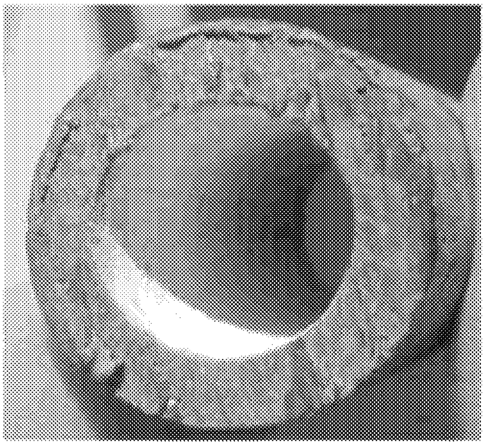
- EPA R5 partnered with CDWM to conduct a sampling study
  - EPA solicited volunteers for sampling study, collected/analyzed samples, measured/estimated LSL lengths at each site
  - Volunteers collected samples from their homes, provided plumbing/other information
  - CDWM provided information on water quality, water mains, service line materials, metering/water usage, work reports on sampling sites

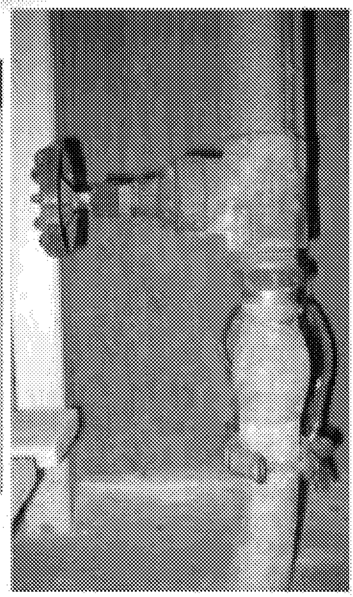
# Overview of Study

- 32 SFRs with LSLs
- 3 rounds of monitoring at most sites
  - Mar/Apr 2011
    - 4 first-draw and 45 sec flushed samples
  - June 2011
    - 12 sequential samples
  - Sept/Oct 2011
    - 11+ sequential samples, 2 first-draw samples, and flushed samples (3 min, 5 min & 7 minute)



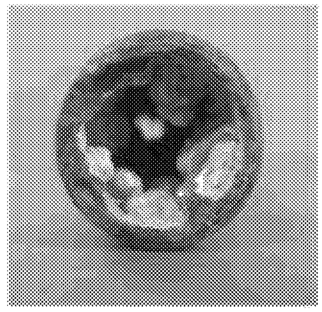
## Lead Service Lines



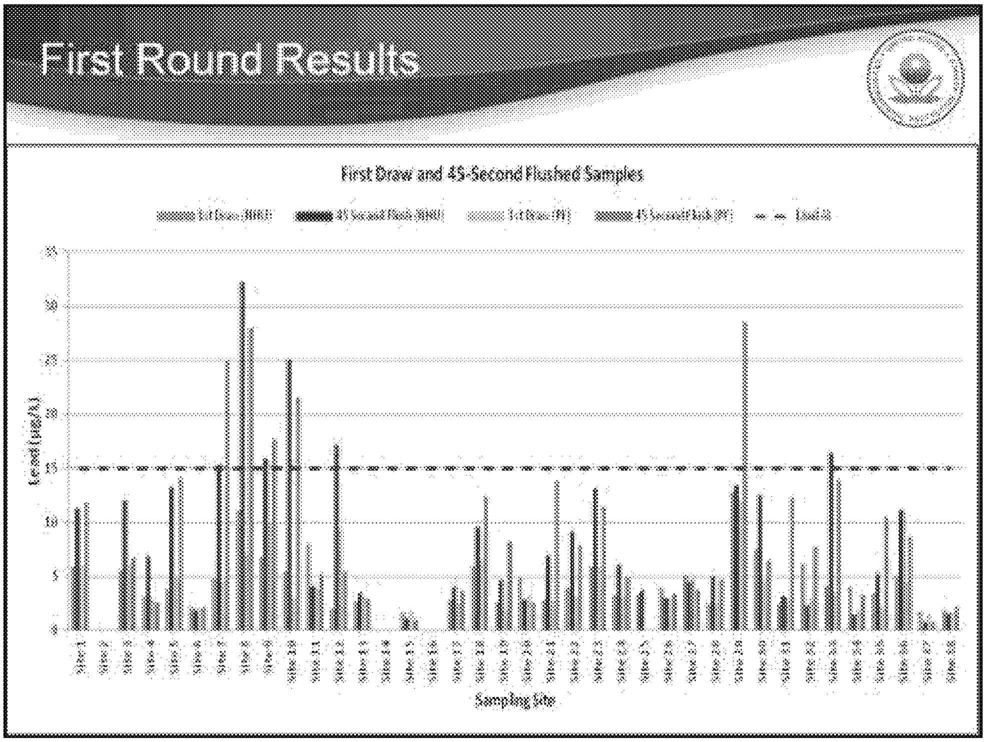


## First Round

- First round (4 samples)
  - First-draw sampling without pre-flush (NHU)
  - 45 second flushed sample following 2nd FD NHU sample
  - First-draw (FD) sampling with 5 min pre-flush (PF)
  - 45 second flushed sample following 1st FD PF sample
- 45 second flushed samples discontinued after first round due to corroded galvanized pipe affecting timing



•The sampling was conducted over two days:
•The first day (without pre-flushing the tap the night before) and following a minimum stagnation time of 6 hours during which residents were instructed not to use water in the home, a first-draw sample was collected, followed by running the water for 45 seconds and collecting a second (45 sec flushed) sample.
•The night before the second set of samples were collected, the tap was flushed for 5 minutes and residents were instructed not to use any water in the home until samples were collected the next day. A minimum stagnation time of 6 hours was used.
•The following day a first-draw sample was collected, followed by running the water for 45 seconds and collecting a second (45 sec flushed) sample.
•Dates/times were recorded by volunteers.
•.




•All First-draw results, with and without pre-flush were below the lead action level.
•At same sites, a number of the 45 second flushes samples following the first-draw samples were above the lead action level.
•Some sites initially thought to have LSLs did not have them and were excluded from further sampling.
•One site initially thought not to have a LSL did have a LSL.
•Results show that EPA's 3-0-45 second flushing instructions before drawing water for consumption can take residents with LSLs to higher lead.

## Overall First-Draw Results

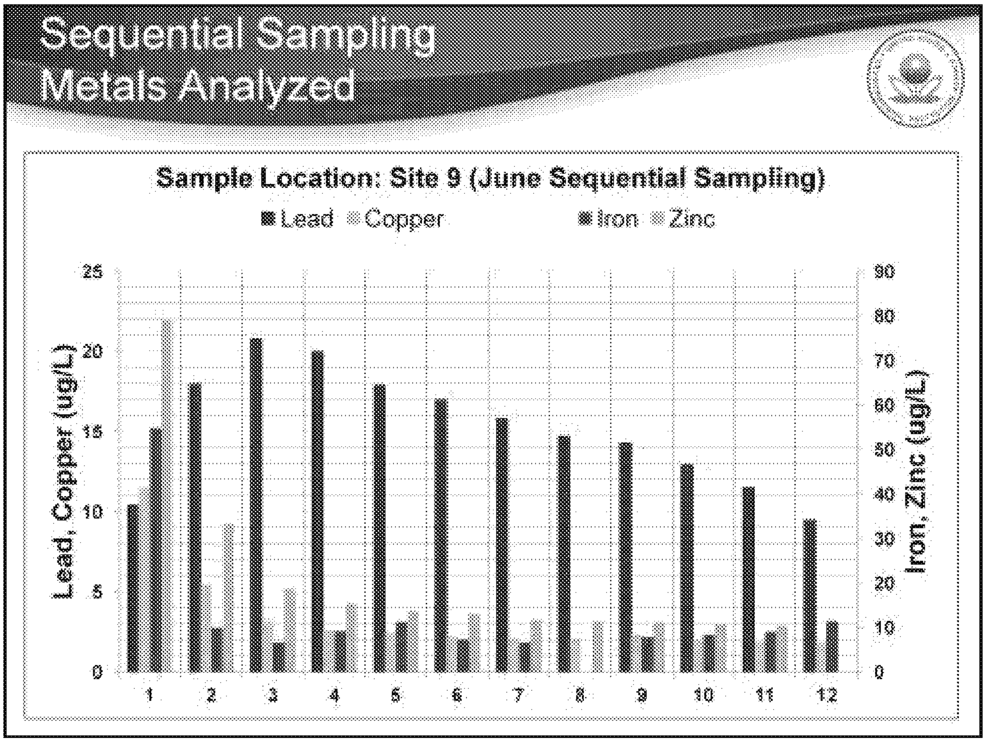
| Summary of NHU and PF First-Draw Results | | | | | |
|---|---|---|---|---|---|
| | NHU (Mar/Apr) | PF (Mar/Apr) | PF (June) | NHU (Sept/Oct) | PF (Sept/Oct) |
| 90th %ile Pb Value (ug/L) | 8 | 7 | 8 | 10 | 9 |
| No. of Samples | 32 | 32 | 28 | 29 | 30 |
| No. Above AL | 0 | 0 | 0 | 2 | 1 |

•The NHU results were higher overall than the corresponding PF values for most sites. The PF first-draw protocol produced lower individual results than NHU first-draw protocol in 23 of 32 sample pairs in March/April, and 20 of 27 sample pairs in Sept/Oct.
•Although NHU first-draw samples were collected without directing the residents to flush the tap, showering, washing dishes or doing laundry prior to the stagnation period could influence NHU first-draw sample results similar to pre-flushing the tap. As shown in Figure 2, higher lead levels were present at the time of sampling than what was captured by either first-draw protocol.
•First-draw results were slightly higher than, but consistent with Chicago's compliance data going back to 1999 (average 90$^{th}$ percentile was 6 ug/L). The first-draw 90$^{th}$ percentile results for all rounds in the study were below the AL with only 3 samples above the AL in all sampling conducted.

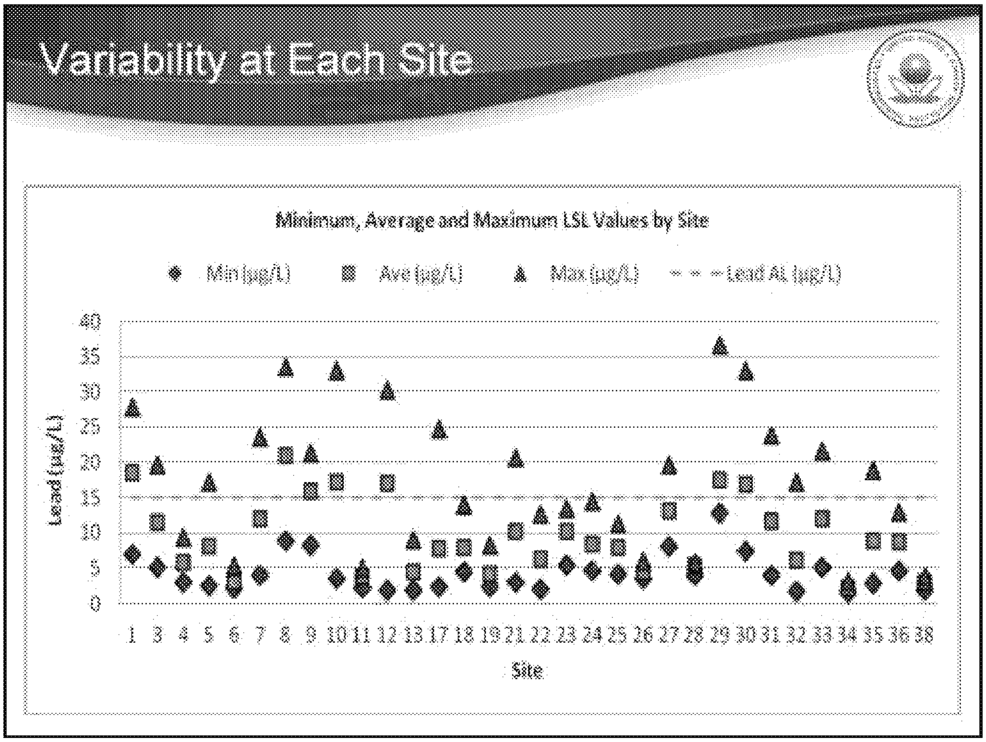
## Sequential Sampling

- 12 sequential one-liter samples were collected in June at each site.
- At least 11 sequential samples were collected in Sept/early Oct at each site.
  - Additional sequential samples were collected at some sites with higher results, but are not used in the analysis to avoid skewing.
- Residents were instructed to flush the tap for 5 minutes the night before and then not to use any water in the household until samples were collected the following morning.

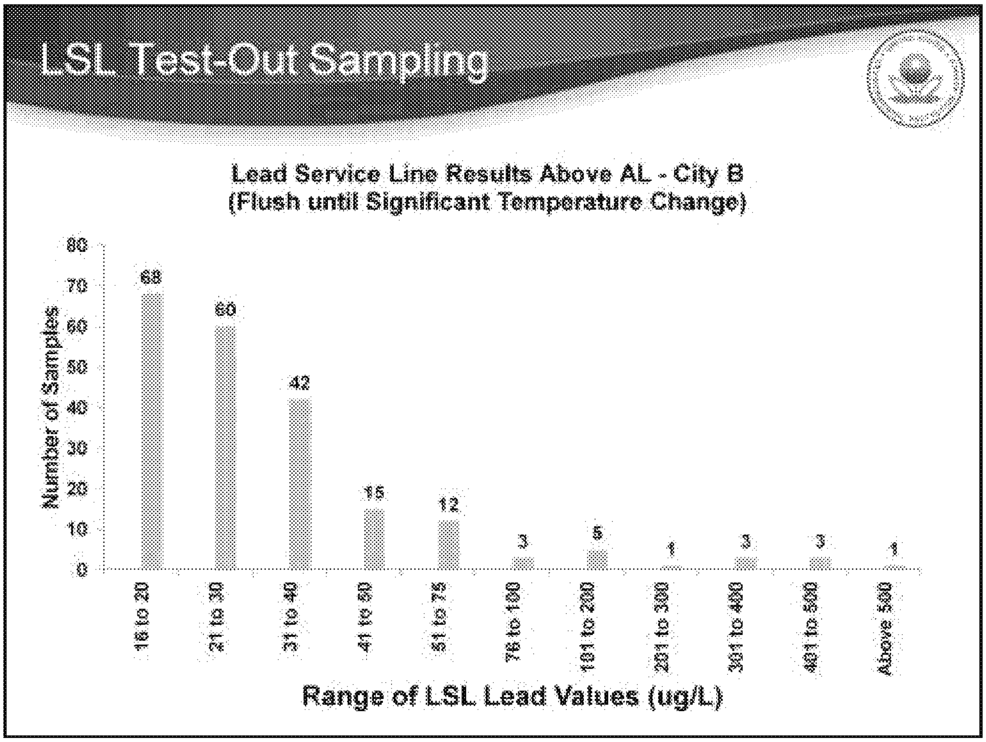
Samples were collected one after the other without turning the water off.



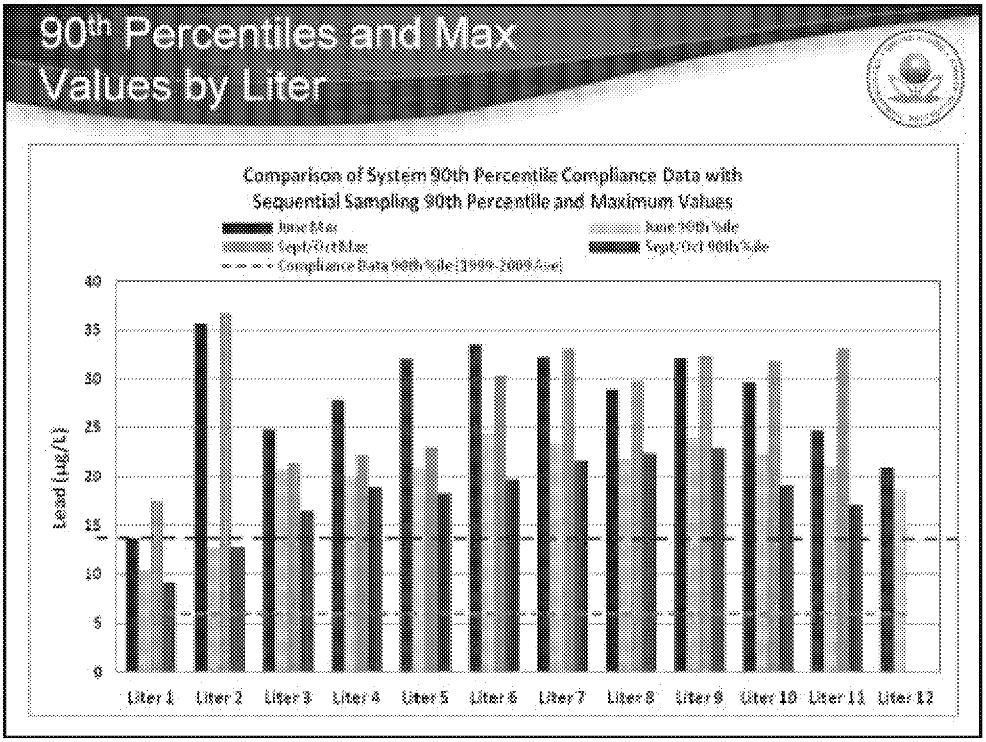

•This is an example of the metals analyses. This site has a short stretch of interior galvanized pipe before hitting the meter and LSL.
•Cu and Zinc indicate brass consistent with the meter.
•Cannot distinguish whether lead is from LSL or meter.
•Beyond the internal plumbing, you see the iron from the galvanized pipe tail off, but can still see the trailers of zinc and iron throughout, indicating the later samples are picking up metals passing through the interior plumbing.
•The trace iron could be from the main (Chicago uses a blended phosphate).




•Using the 12 sequential samples from June and first 11 samples from Sept/Oct, the chart shows the variability of lead levels at each site.
•Many sites would be over or under the lead action level, depending on the liter selected as the compliance sample.
•The length of pipe to the beginning of the LSL was also widely variable. In some places, the LSL was hit in the 1st/2nd liter, but at most sites there was a variable length of internal plumbing before hitting the LSL.




•This is data from a second system that exceeded the Pb AL and had to undertake LSLR activities.
•Sampling protocol was from LCR (flush until significant change in temperature).
•Results show significant variability in LSL lead levels across the system.
•Total number of samples collected was 1925; with 1,762 results (89%) below the lead AL; and 213 results (11%) above the lead AL.
•LSL results above the AL ranged from 16 µg/L to 580 µg/L with 28 sample results in exceedance of 50 µg/L.




•This chart plots all results for the same liter across all sample sites and shows the 90th percentile values and max values if a specific liter were used for calculating the 90th percentile value for the system.
•The initial and final liters are likely biased low because they capture interior plumbing after pre-flushing and some of the shorter LSL sites may capture water from within the water main.

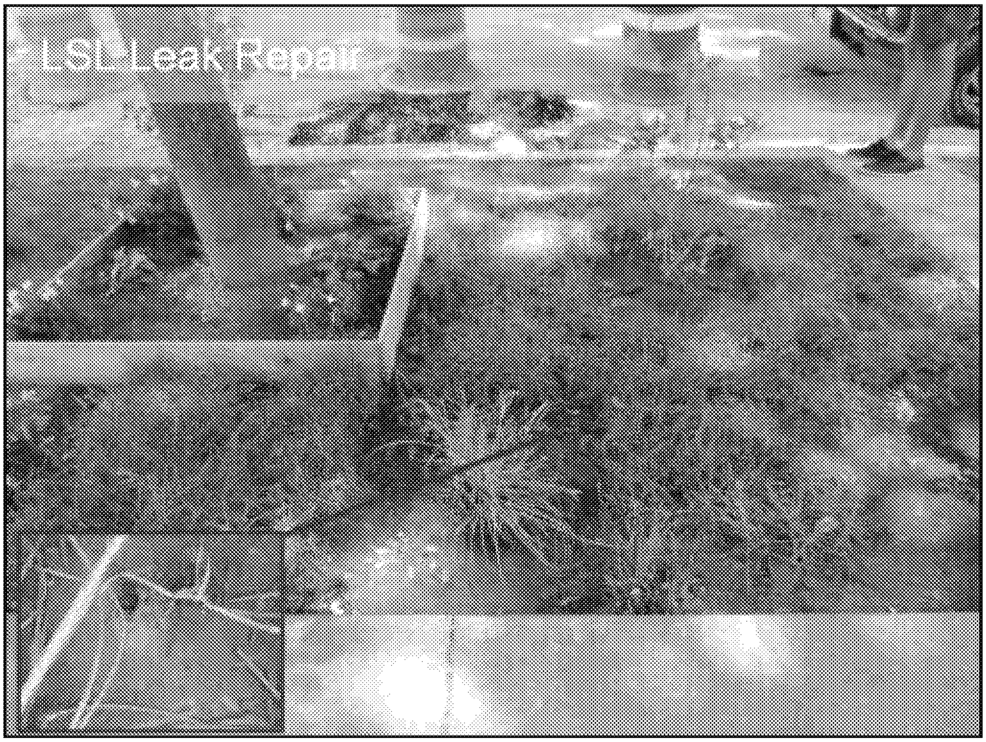
## LSL Disturbances

- Disturbed Sites
  - meter installation or replacement
  - auto-meter-reader (AMR) installation
  - service line leak repair
  - external service shut-off valve repair or replacement
  - significant street excavation directly in front of the home that could disturb the LSL
- Undisturbed Sites
  - Un-metered site
  - No CDWM record of disturbance
  - No resident recollection of any disturbance, as defined above
- Indeterminate Site
  - Sites where CDWM has no record of any LSL disturbance, and the resident did not provide a response as to whether there has been any LSL disturbance

•We use the third category because the cross-checking was important.
•It's good to ask residents for information. In some cases, residents provided information that was not reflected in CDWM records. Upon further investigation, CDWM information resulted in reclassification of the site.

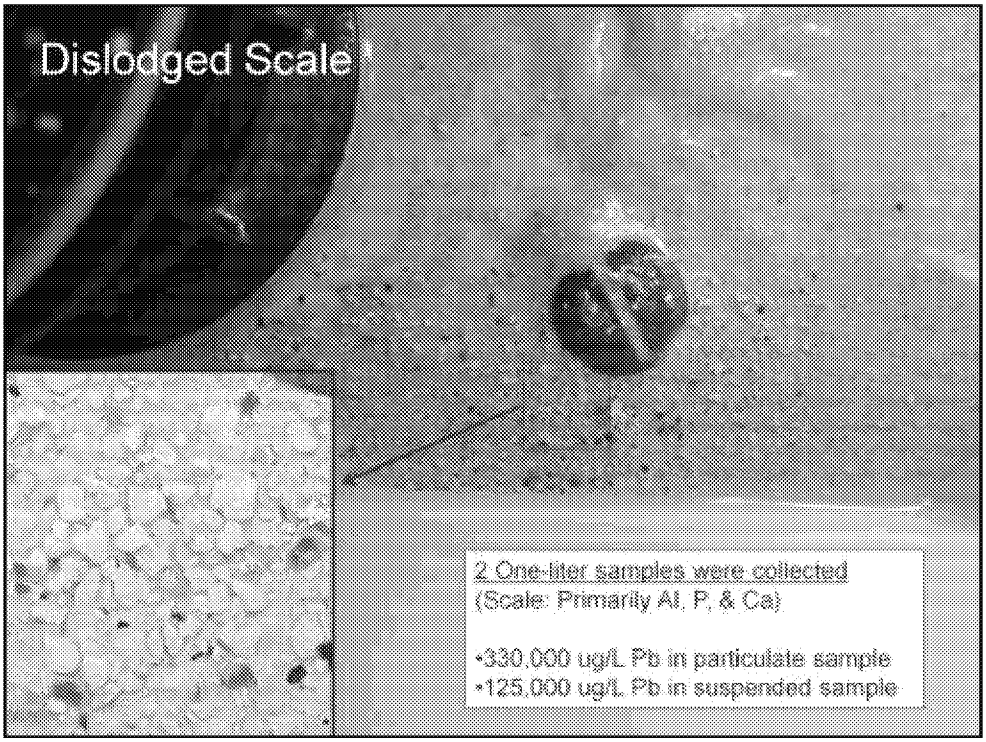
# LSL Disturbances

| | | |
|---|---|---|
| # of Disturbed Sites | 13 | % of Samples over AL: 36% |
| Total Samples Collected | 327 | |
| # Samples Above AL | 117 | |
| # of Undisturbed Sites | 16 | % of Samples over AL: 2 % |
| Total Samples Collected (Undisturbed) | 372 | |
| # Samples above AL | 6 | |
| # of Indeterminate Sites | 3 | % of samples over AL: 37% |
| Total Samples Collected | 81 | |
| # Samples above AL | 30 | |

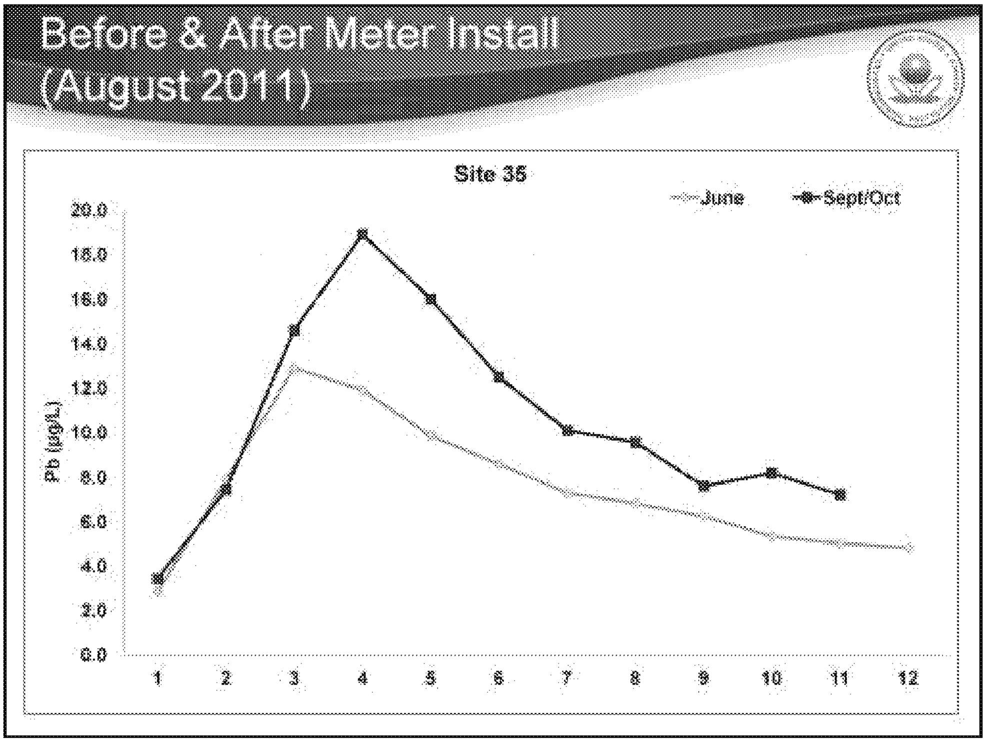



•During water main work, the jarring about 12 feet away in the street sprung a leak in the lead service line at the service shut-off valve (solder joint).
•Water was bubbling up to the surface.

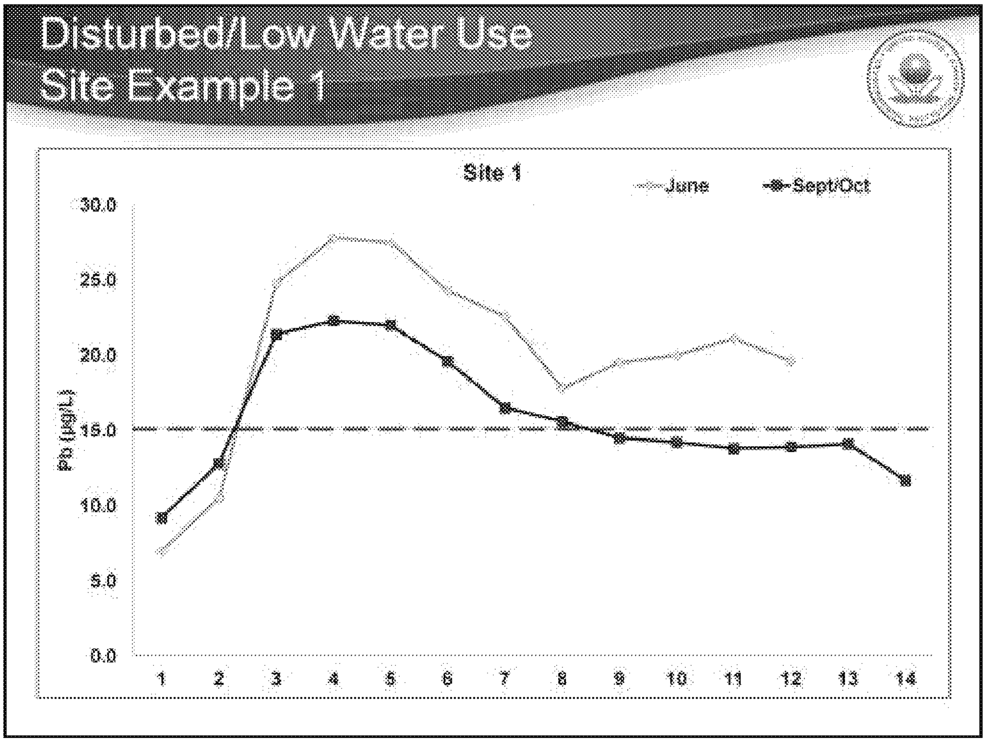
# Fixing the LSL Leak



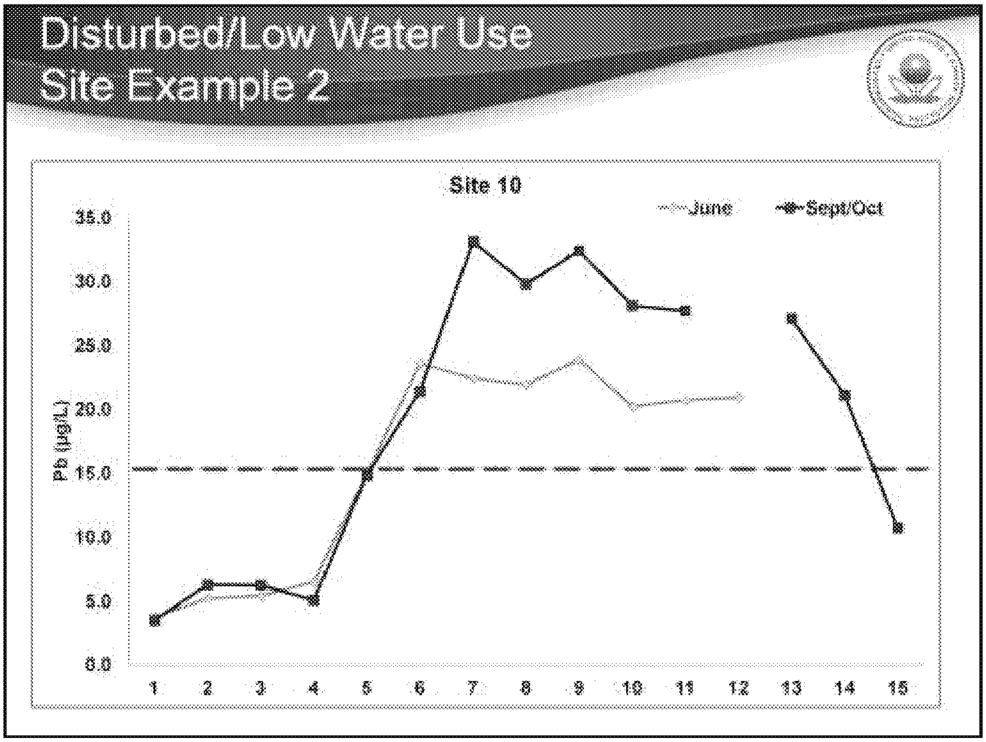

Using an improvised particulate collection system, the particles were collected into a one-liter sample bottle filled with the tank water. The remaining water with suspended particles was collected into a second one-liter bottle.




A meter was installed in a meter pit in front of this home in August (in-between sequential sampling events).




Meter Install, apparent normal water use. Information provided by resident indicates low daily use almost all of the time and incidences of high volume use over 1-2 day periods.




LSL leak repair, average monthly water use was 1,826 gallons.
This and some other sites were why we collected additional sequential samples at some sites, to inform residents as when the levels came down.

## Preparing for Publication

- Peer review comments received on manuscript
  - Due date for revised manuscript is April 24
  - If revisions/responses are acceptable, posting to ES&T website could happen shortly thereafter (within days)
- Meanwhile…
  - R5 is developing a website with information on lead service lines
  - Preparing a desk statement (will coordinate with Chicago, IEPA, EPA HQ)

## Additional Chicago Activities

- Add Chgo slides

# Detection and Evaluation of Elevated Lead Release from Service Lines: A Field Study

(Supplemental Information for Manuscript ID: es-2013-003636)

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**The supplemental information provides additional background information, summaries and graphics for the underlying data used in the study.**

| **Summary of Supplemental Figures and Tables** | | | |
|---|---|---|---|
| **Figures** | | **Tables** | |
| Figure S1 | Plumbing Profile Diagram | Table S1 | LSL Lengths |
| Figure S2 | Photograph of LSL Bulb | Table S2 | Chicago Compliance Data |
| Figure S3 | Photograph of LSL Segment | Table S3 | Summary of Samples Collected |
| Figure S4 | Photograph of Corroded Galvanized Pipe | Table S4a | First-draw and Second-draw (45 second flushed) Sample Results |
| Figure S5 | Sample Site Map and Home Age | Table S4b | Comparison of LCR-equivalent $90^{th}$ percentile results using alternative first-draw protocols. |
| Figure S6 | Graph of Four Metals for Site 9 | Table S5 | June Sequential Sampling Results |
| Figure S7 | City B Sampling Instructions | Table S6a | Sept/Oct Sequential Sampling Results Used in Analyses |
| Figure S8 | City B LSL Results | Table S6b | Sept/Oct Supplemental Sequential Sampling Results (Not Used in Analyses) |
| Figure S9-S40 | Sequential Sampling Graphs (Lead) | Table S6c | Summary of stagnation times. |
| Figure S41 | Mar/Apr Sampling Instructions | Table S6d | Seasonal variability effects observed |
| Figure S42 | Mar/Apr Sample Collection and Reporting Form | Table S7 | Flushed Sampling Results |
| Figure S43 | June Sampling Instructions and Sample Collection and Reporting Form | Table S8 | Summary of Disturbed, Undisturbed and Indeterminate Sites |
| Figure S44 | Sept/Oct Sampling Instructions | Table S9 | City B Compliance Data |
| Figure S45 | Sept/Oct Sample Collection and Reporting Form | | |

## Background

The Lead and Copper Rule (LCR) is a treatment technique regulation that requires all public water systems to optimize corrosion control and utilizes tap sampling for lead and copper to determine whether additional actions need to be taken by the system. It is important to note that the sampling conducted under the LCR is not designed to evaluate individual consumers' lead exposure or risk and that the lead action level (AL) was not established as a health-based number. The lead AL is the level which EPA determined in 1991 that systems could feasibly meet, taking into account the available treatment technologies and the cost of those treatment technologies. The lead AL should not be viewed or used as a threshold value to determine whether the water is safe or unsafe to drink, and it should be reiterated that the EPA and CDC have determined that there is no safe level of lead exposure (i.e., no level at which there is not an adverse effect).

Tap sampling conducted under the LCR is intended to measure the amount of lead and copper corrosion that is occurring in public water systems using worst-case site selection and a specified sampling protocol. The sampling protocols in the current LCR were established in 1991, based on the existence of many potential sources of lead throughout the water distribution system, including lead service lines connecting the water main to the homes, leaded-solder used to join copper pipe, and leaded-brass devices, such as meters, brass connectors and shut-off valves, faucets and fixtures. The current LCR sampling requirements are prescriptive and based on the relative significance of lead sources in 1991. The sequential sampling protocol (described below, and in the accompanying paper) that resulted in capturing the highest lead, as well as the sample results themselves, are not allowed to be used in the current compliance calculation.

The LCR utilizes a combination of: worst-case site selection (sites expected to yield the highest lead results); sampling protocols used to capture the highest lead; and repeated sampling at the same sites in order to measure the level of lead corrosion that is occurring throughout the water distribution system. Utilizing this sampling structure allows U.S. EPA to keep the sampling burden on public water systems manageable, while still accomplishing the objectives of the sampling under the LCR. Absent these key components, the number of samples needed to accurately assess system-wide corrosion would necessarily need to increase substantially to accomplish the objectives of the LCR.

The action level for lead is 0.015 mg/L, but is presented here as 15 μg/L for the purpose of using consistent units for the data. An exceedance of the lead AL based on the sampling triggers specific actions that a public water system must undertake to protect public health, such as installing or adjusting corrosion control treatment and providing public education. Additionally, where the corrosion control treatment has proven ineffective at lowering lead levels below the lead AL, the removal of lead service lines is triggered. There are many different corrosion mechanisms and factors that govern lead corrosion. The selection of sampling sites, sampling protocol, and site conditions are essential components for evaluating the level of corrosion that is occurring in the distribution system, regardless of the mechanism(s) or contributing factor(s). It is therefore critically important that the sampling protocol accurately portray the level of corrosion that is occurring.

## Lead Service Line and Plumbing Information

As part of the sampling protocol, residents were asked to provide a plumbing profile (figure S1), describing their internal plumbing, and identifying the location of the kitchen tap, and shut-off valve/meter.

**Volunteer ID:** ______________

**Home Plumbing and Service Line Diagrams**

Below there are 4 diagrams for common household plumbing configurations and the 5th diagram is blank. Please review the diagrams and select the diagram that best matches the plumbing configuration for your home. Each of the diagrams shows where the water service line comes into the home and where the kitchen tap is located. If none of the four diagrams matches your home, use the blank diagram (number 5) to draw where the water service line comes into your home and where your kitchen tap is located. If you do not know where the service line comes into the home, you can note that in your Home Plumbing description below.

**Note:** Some homes have water meters and some do not. On the diagrams below, if you do not have a water meter, pick the diagram that matches where your service line comes into your home and where the kitchen tap is, and cross out the meter symbol

**Home Plumbing Description:** In the space below, please describe your home plumbing as best you can, from the point at which the water service line comes into your home to the location of your kitchen tap (length of pipe, diameter of pipe, pipe material, etc.):

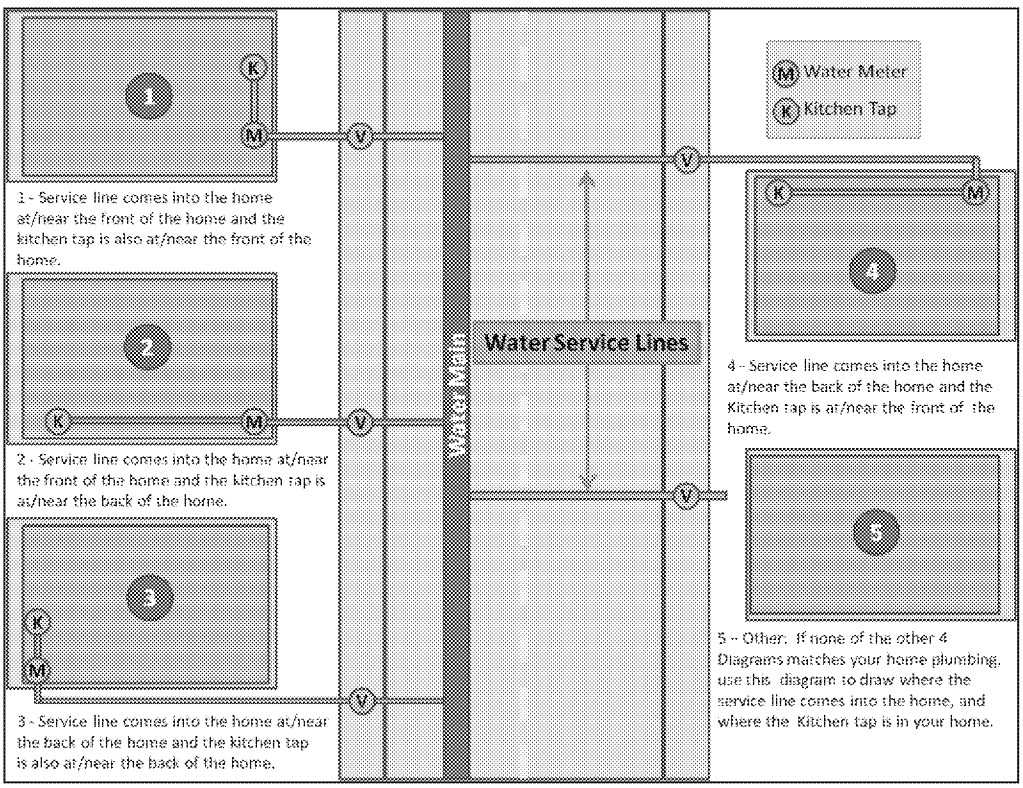



**Figure S1: Plumbing Profile Diagram**

Table S1 contains a summary of the LSL information for each sampling site. Due to the site-specific plumbing characteristics, the liter which first begins to capture LSL water at each site was expected to be variable, as was the liter which would begin to collect uncontaminated water from the water mains. The study findings regarding whether the current sampling protocol is capturing the corrosion that is occurring are not affected by this limitation.

| Site | LSL Length ft (meters) | LSL End Point | Site | LSL Length ft (meters) | LSL End Point |
|---|---|---|---|---|---|
| 1 | 89 (27.1) | BFW | 22 | 65 (19.8) | IFW |
| 3 | 73 (22.3) | IFW | 23 | 66 (20.1) | IFW |
| 4 | Unknown | Unknown | 24 | 56 (17.1) | IFW |
| 5 | 80 (24.4) | IBW | 25 | 70 (21.3) | IFW |
| 6 | 60 (18.3) | IFW | 26 | 66 (20.1) | IFW |
| 7 | 59+ (18.0+) | BFW | 27 | 47+ (14.3+) | Unknown |
| 8 | 57 (17.4) | IFW | 28 | 61+ (18.6+) | Unknown |
| 9 | 102 (31.1) | BFW | 29 | 159 (48.5) | BFW |
| 10 | 48+ (14.6+) | IFW | 30 | 49+ (14.9+) | Unknown |
| 11 | 50 (15.2) | IFW | 31 | 71+ (21.6+) | IFW |
| 12 | 53 (16.2) | IFW | 32 | 43 (13.1) | IFW |
| 13 | 49+ (14.9+) | Unknown | 33 | 43+ (13.1+) | IFW |
| 17 | 58+ (17.7+) | Unknown | 34 | Unknown | Unknown |
| 18 | 76 (23.2) | IFW | 35 | 80 (24.4) | BFW |
| 19 | 63(19.2) | IFW | 36 | 110 (33.5) | IBW |
| 21 | 46 (14.0) | IFW | 38 | 51 (15.5) | IFW |

IFW = LSL ends just inside the front wall
IBW = LSL ends just inside the back wall
BFW = LSL ends at an unknown distance beyond the front wall
**+ =** Indicates that the LSL was measured from the water main to the front the home, and it is not known whether the LSL extends beyond the front wall of the home.

**Table S1:** LSL Lengths – The length of the LSLs for most sites were measured and are presented in this table. The LSLs for two sites (site 4 and site 34) were not measured.

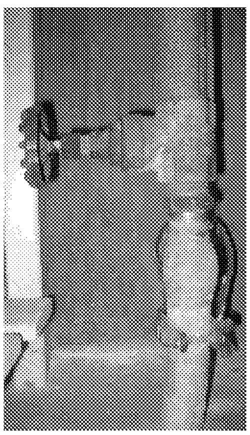


**Figure S2:** LSL Bulb

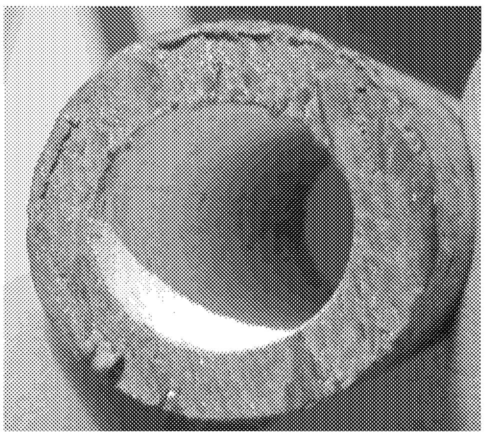


**Figure S3:** LSL segment (3/4 inch / 1.91 cm diameter)

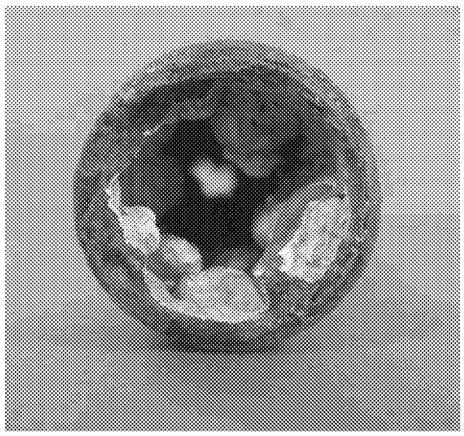


**Figure S4:** Severely corroded galvanized iron pipe.

Figure S2 shows a typical LSL in Chicago coming up from the foundation of the basement. The lead service line is a dull gray and easily scratched with a key. The soft LSL is typically soldered to the interior (household) plumbing, leaving a characteristic bulb. The LSL can also be connected to household pipe using a brass compression fitting.

Figure S3 is a close-up of a 3/4 inch (1.91 cm) diameter LSL, showing the thickness of a typical LSL.

Figure S4 is a cross-section of a severely corroded galvanized pipe from one of the sample sites. In this photograph the inner diameter is significantly reduced which affects the volume of water that will flow through the pipe in a set amount of time. For homes with corroded galvanized pipe, water will flow slower through the pipe and longer flushing times are generally needed to flush the lead from the plumbing.

## City Information

Samples were collected from 32 single-family homes in Chicago with LSLs. Twenty-three homes were in the Jardine Plant service area and nine homes were in the South Plant service area.

| Site # | Home Built | Service Area |
|---|---|---|
| 01 | 1893 | Jardine |
| 03 | 1960 | Jardine |
| 04 | 1941 | South |
| 05 | 1901 | South |
| 06 | 1953 | Jardine |
| 07 | 1900 | Jardine |
| 08 | 1941 | Jardine |
| 09 | 1920 | Jardine |
| 10 | 1943 | Jardine |
| 11 | 1912 | Jardine |
| 12 | 1952 | Jardine |
| 13 | 1950 | South |
| 17 | 1907 | Jardine |
| 18 | 1953 | Jardine |
| 19 | 1912 | Jardine |
| 21 | 1938 | Jardine |
| 22 | 1924 | Jardine |
| 23 | 1944 | South |
| 24 | 1906 | Jardine |
| 25 | 1917 | South |
| 26 | 1954 | South |
| 27 | 1891 | Jardine |
| 28 | 1932 | Jardine |
| 29 | 1890 | Jardine |
| 30 | 1954 | South |
| 31 | 1923 | Jardine |
| 32 | 1923 | South |
| 33 | 1927 | Jardine |
| 34 | 1915 | Jardine |
| 35 | 1900 | Jardine |
| 36 | 1957 | South |
| 38 | 1927 | Jardine |

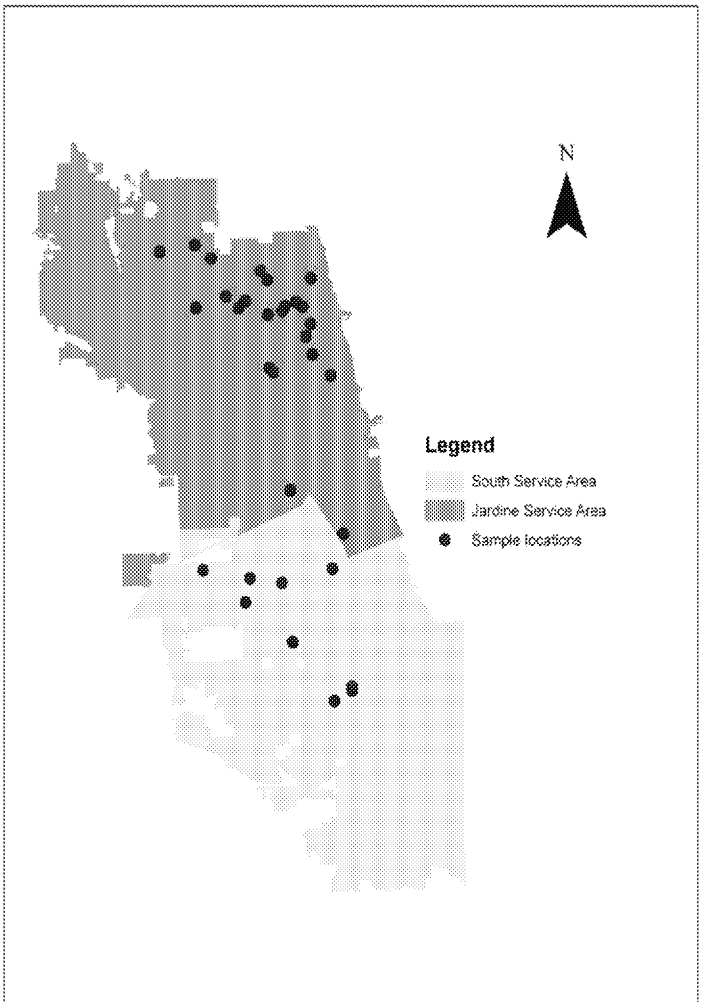



**Figure S5:** Home age and plant service areas for sampling locations

Table S2 contains a summary of the City's compliance monitoring data for lead. The City exceeded the lead AL only once, during the July-December 1992 compliance monitoring period.

| City of Chicago (1992 – 2010) $90^{th}$ Percentile Lead Values (µg/L) | | | |
|---|---|---|---|
| **Monitoring Period Begin** | **Monitoring Period End** | **Number of Samples** | **90th Percentile Value** |
| 1/1/2008 | 12/31/2010 | 50 | 6 |
| 1/1/2005 | 12/31/2007 | 50 | 6 |
| 1/1/2002 | 12/31/2004 | 50 | 4 |
| 1/1/1999 | 12/31/2001 | 50 | 7 |
| 1/1/1999 | 12/31/1999 | 50 | 8 |
| 1/1/1998 | 12/31/1998 | 53 | 14 |
| 7/1/1997 | 12/31/1997 | 100 | 11 |
| 1/1/1997 | 6/30/1997 | 100 | 10 |
| 1/1/1993 | 6/30/1993 | 100 | 13 |
| 7/1/1992 | 12/31/1992 | 120 | **20** |
| 1/1/1992 | 6/30/1992 | 100 | 10 |

**Table S2:** City of Chicago $90^{th}$ Percentile Compliance Values (1992 – 2010)

## Laboratory and Analytical Information

All samples were inspected for visible particulates prior to delivery to the laboratory. In light of the significant increase in visible particulate in the final round of monitoring, the presence of fine particulates that would readily dissolve in the nitric acid preservative should not be discounted. Samples collected during the final round of monitoring coincided with the Fire Department's annual valve exercising. Colloidal lead may explain some of the variability in lead levels between the June and Sept/Oct rounds.

Laboratory blanks, laboratory fortified blanks and laboratory fortified samples were run at a frequency of at least one per twenty samples. Laboratory blanks run with the samples did not have any detections of lead above the reporting limit and all Laboratory fortified blanks and laboratory fortified samples had recoveries greater than 90%.

All laboratory instrumentation was inspected and maintained according to Chicago Regional Laboratory maintenance protocols, and calibrated daily according to Chicago Regional Laboratory standard operating procedures.

The Chicago Regional Lab Quality Assurance (QA) Contact performed a data quality assessment on the results based on laboratory blanks, laboratory fortified blanks and matrix spikes. The QA Contact identified no biases in the sample results due to these quality control measurements.

## Sampling Summaries

***Sample site summary table*** - A summary table of the types of samples collected at each site, for each sampling protocol is presented in Table S3 below. The highlighted rows for Sites 2, 14, 15, 16 & 37 were confirmed not to have LSLs and Site 20 is the same residence as Site 21 (Kitchen tap and bathroom tap). Following the first round of sampling, Site 20 (bathroom tap) was no longer sampled, to maintain consistency of using kitchen taps across all sites. Only sample results from LSL sites are presented and analyzed in the study paper. The first liter of the sequential samples in June and Sept/Oct also serve as the PF first-draw samples.

| Summary of Samples Collected at Each Site | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site # | Total # Samples | Mar/April | | June | Sept/Oct | | |
| | | Day 1 | Day 2 | Day 1 | Day 1 | Day 2 | Day 3 |
| 01 | 34 | A, C | B, D | E-12 samples | A | E-14 samples | F, G, H |
| 02 | 16 | A, C | B, D | E-12 samples | DNS | DNS | DNS |
| 03 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 04 | 16 | A, C | B, D | E-11 samples | DNS | DNS | DNS |
| 05 | 28 | A, C | B, D | E-12 samples | A | E-11 samples | DNS |
| 06 | 28 | A, C | B, D | E-12 samples | A | E-11 samples | DNS |
| 07 | 35 | A, C | B, D | E-12 samples | A | E-15 samples | F, G, H |
| 08 | 35 | A, C | B, D | E-12 samples | A | E-15 samples | F, G, H |
| 09 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 10 | 34 | A, C | B, D | E-12 samples | A | E-14 samples | F, G, H |
| 11 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 12 | 34 | A, C | B, D | E-12 samples | A | E-14 samples | F, G, H |
| 13 | 16 | A, C | B, D | DNS | A | E-11 samples | DNS |
| 14 | 4 | A, C | B, D | DNS | DNS | DNS | DNS |
| 15 | 4 | A, C | B, D | DNS | DNS | DNS | DNS |
| 16 | 4 | A, C | B, D | DNS | DNS | DNS | DNS |
| 17 | 34 | A, C | B, D | E-12 samples | A | E-14 samples | F, G, H |
| 18 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 19 | 27 | A, C | B, D | E-12 samples | DNS | E-11 samples | DNS |
| 20 | 4 | A, C | B, D | DNS | DNS | DNS | DNS |
| 21 | 28 | A, C | B, D | E-12 samples | A | E-11 samples | DNS |
| 22 | 28 | A, C | B, D | E-12 samples | A | E-11 samples | DNS |
| 23 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 24 | 33 | A, C | B, D | E-12 samples | A | E-14 samples | F, G |
| 25 | 16 | A, C | B, D | E-12 samples | DNS | DNS | DNS |
| 26 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 27 | 33 | A, C | B, D | E-12 samples | A | E-14 samples | F, G |
| 28 | 30 | A, C | B, D | DNS | A | E-11 samples | F, G |
| 29 | 40 | A, C | B, D | E-12 samples | A | E-20 samples | F, G, I |
| 30 | 18 | A, C | B, D | DNS | A | E-11 samples | F, G |
| 31 | 31 | A, C | B, D | E-12 samples | A | E-12 samples | F, G |
| 32 | 28 | A, C | B, D | E-12 samples | A | E-11 samples | DNS |
| 33 | 33 | A, C | B, D | E-12 samples | A | E-14 samples | F, G |
| 34 | 18 | A, C | B, D | DNS | A | E-11 samples | F, G |
| 35 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 36 | 30 | A, C | B, D | E-12 samples | A | E-11 samples | F, G |
| 37 | 4 | A, C | B, D | DNS | DNS | DNS | DNS |
| 38 | 16 | A, C | B, D | E-12 samples | DNS | DNS | DNS |

A = NHU First-draw Sample
B = PF First-draw Sample
C = NHU 45-Second Flushed Sample
D = PF 45-Second Flushed Sample
E = Sequential Sample
F = 3-minute Flushed Sample
G = 5-minute Flushed Sample
H = 7-minute Flushed Sample
I = 10-minute Flushed Sample
DNS = Site did not sample

**Table S3:** Summary of samples collected at each site using each sampling protocol.

***First-draw and 45-second flushed samples*** – Results for first-draw and 45-second flushed samples using the normal household use (NHU) and pre-flushed (PF) sampling protocols are presented in Table S4 below.

In addition to the first-draw samples, a 45-second flush sample was collected by running the water for 45 seconds immediately following the collection of the NHU first-draw and PF first-draw samples during the March/April sampling. Overall, the 45-second flush sample results were higher than the first-draw results, and yielded a higher percentage of results above the lead AL. A total of 32 NHU/45-second flushed and 32 PF/45-second flushed samples were collected, with 6 NHU 45-second flushed results above the lead AL (19%), and 5 PF/45-second flushed results above the AL (16%). The total number of 45-second flush sample results above the lead AL was 11 of 64 (17%); a percentage significantly higher than the first-draw results (2%).

| First-draw and 45-second Flushed Sample Lead Results (μg/L) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site | A (Mar/Apr) | C (Mar/Apr) | B (Mar/Apr) | D (Mar/Apr) | B (June) | A (Sept/Oct) | B (Sept/Oct) |
| 1 | 5.93 | 11.3 | 5.94 | 11.9 | 6.98 | 7.37 | 9.19 |
| 3 | 5.60 | 12.0 | 6.01 | 6.71 | 5.82 | 10.0 | 8.28 |
| 4 | 3.25 | 6.76 | 3.12 | 2.56 | 3.61 | DNS | DNS |
| 5 | 3.84 | 13.2 | 4.97 | 14.1 | 2.56 | 3.04 | 2.76 |
| 6 | 2.31 | 1.90 | 2.07 | 2.13 | 2.50 | 2.44 | 2.25 |
| 7 | 4.74 | 15.3 | 4.62 | **24.9** | 4.91 | 5.12 | 4.03 |
| 8 | 11.2 | **32.2** | 7.12 | **28.0** | 11.1 | **17.5** | 9.24 |
| 9 | 6.82 | **15.9** | 9.80 | **17.7** | 10.4 | 15.3 | 8.29 |
| 10 | 5.46 | **25.0** | 3.06 | **21.6** | 3.70 | 4.98 | 3.46 |
| 11 | 8.08 | 4.13 | 3.85 | 5.30 | 2.15 | 3.53 | 2.96 |
| 12 | 1.99 | **17.2** | 9.36 | 5.45 | 1.80 | 2.27 | 5.35 |
| 13 | 2.68 | 3.50 | 3.05 | 2.94 | DNS | 2.53 | 1.88 |
| 17 | 2.83 | 4.00 | 2.50 | 3.70 | 2.37 | 2.65 | 2.73 |
| 18 | 5.98 | 9.57 | 6.60 | 12.4 | 4.55 | 5.80 | 4.75 |
| 19 | 2.59 | 4.69 | 1.92 | 8.27 | 2.90 | DNS | 3.01 |
| 21 | 2.81 | 6.87 | 2.60 | 13.8 | 3.16 | 4.13 | 2.99 |
| 22 | 3.91 | 9.19 | 3.36 | 7.93 | 2.06 | 3.21 | 2.29 |
| 23 | 5.97 | 13.1 | 5.80 | 11.5 | 8.30 | 9.16 | 7.02 |
| 24 | 3.33 | 6.10 | 3.05 | 4.98 | 4.63 | 7.57 | 6.62 |
| 25 | 3.41 | 3.75 | ND | ND | 4.28 | DNS | DNS |
| 26 | 3.89 | 3.02 | 3.12 | 3.45 | 3.51 | 4.53 | 4.88 |
| 27 | 5.19 | 4.53 | 5.36 | 3.76 | 8.06 | 8.30 | 12.6 |
| 28 | 2.51 | 4.99 | 2.47 | 4.70 | DNS | 4.26 | 3.94 |
| 29 | 12.8 | 13.5 | 12.1 | **28.6** | 13.7 | 1.9 | 17.6 |
| 30 | 7.56 | 12.5 | 4.72 | 6.52 | DNS | 8.39 | 7.88 |
| 31 | 2.53 | 3.16 | 2.92 | 12.3 | 4.03 | 4.67 | 5.97 |
| 32 | 6.18 | 2.29 | 2.90 | 7.82 | 3.08 | 3.36 | 2.94 |
| 33 | 4.25 | **16.4** | 3.51 | 14.0 | 5.18 | 5.55 | 5.52 |
| 34 | 4.12 | 1.51 | 1.88 | 3.30 | DNS | 2.07 | 1.52 |
| 35 | 3.53 | 5.28 | 2.04 | 10.5 | 2.86 | 5.02 | 3.44 |
| 36 | 5.11 | 11.1 | 4.56 | 8.76 | 5.02 | 5.88 | 4.61 |
| 38 | 1.87 | 1.60 | 1.66 | 2.30 | 1.92 | DNS | DNS |
| Ave | 4.76 | 9.23 | 4.25 | 9.74 | 4.82 | 5.73 | 5.45 |
| n | 32 | 32 | 32 | 32 | 28 | 28 | 29 |
| A = NHU First-draw Sample<br>B = PF First-draw Sample<br>C = NHU 45-Second Flushed Sample | | | | D = PF 45-Second Flushed Sample<br>DNS = Site did not sample<br>n = number of samples collected | | | |

**Table S4a:** First-Draw and 45-Second Flushed Sampling Results. Samples that were above the lead AL are in bold, and samples that contained visible particulates are shaded yellow.

| Summary of NHU and PF First-Draw Results | | | | | |
|---|---|---|---|---|---|
| | NHU (Mar/Apr) | PF (Mar/Apr) | PF (June) | NHU (Sept/Oct) | PF (Sept/Oct) |
| 90th %ile Pb Value (µg/L) | 8 | 7 | 8 | 10 | 9 |
| No. of Samples | 32 | 32 | 28 | 29 | 30 |
| No. > AL | 0 | 0 | 0 | 2 | 1 |

**Table S4b:** Comparison of LCR-equivalent 90th percentile results using alternative first-draw protocols.

***Sequential sampling results (June 2011)*** – The sequential sampling approach provided a more reliable (volumetric) method for assessing corrosion as compared to a flushed (time-based) approach. Attempting to characterize the flow at each site would require an evaluation of the plumbing materials and dimensions, as well as the condition of the plumbing materials at each site, is not a feasible or reliable protocol for compliance monitoring.

The results of the each liter in the sequential sampling conducted in June are tabulated below in Table S5 by site.

| **June Sequential Sampling Results by Site/Liter** (µg/L) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Liter** | | | | | | | | | | | |
| **Site** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| 01 | 6.98 | 10.5 | **24.8** | **27.8** | **27.5** | **24.3** | **22.6** | **17.8** | **19.5** | **20.0** | **21.1** | **19.6** |
| 03 | 5.82 | 8.91 | 9.18 | 10.2 | 13.1 | 14.6 | 14.4 | 12.9 | 12.1 | 11.6 | 10.7 | 9.34 |
| 04 | 3.61 | 5.56 | | 7.17 | 8.90 | 9.41 | 8.78 | 8.30 | 5.14 | 3.59 | 3.11 | 2.96 |
| 05 | 2.56 | 6.73 | 14.0 | **17.3** | **16.5** | 9.85 | 6.72 | 6.29 | 6.01 | 5.73 | 5.65 | 5.60 |
| 06 | 2.50 | 2.23 | 2.28 | 2.57 | 2.44 | 2.75 | 2.65 | 2.59 | 3.57 | 5.26 | 4.67 | 4.80 |
| 07 | 4.91 | 5.45 | 6.28 | 6.73 | 7.03 | **22.9** | **23.6** | **19.7** | **16.3** | **16.2** | **16.7** | 14.6 |
| 08 | 11.1 | 12.8 | **21.6** | **19.7** | **32.0** | **33.5** | **32.2** | **28.9** | **32.1** | **29.7** | **24.2** | **18.7** |
| 09 | 10.4 | **18.0** | **20.8** | **20.0** | **17.9** | **17.0** | **15.8** | 14.7 | 14.3 | 12.9 | 11.5 | 9.48 |
| 10 | 3.70 | 5.20 | 5.39 | 6.49 | 14.9 | **23.6** | **22.4** | **21.9** | **23.9** | **20.2** | **20.7** | **20.9** |
| 11 | 2.15 | 2.58 | 2.76 | 2.97 | 3.36 | 3.61 | 3.73 | 3.82 | 4.28 | 4.11 | 4.11 | 4.43 |
| 12 | 1.80 | 2.95 | 3.55 | 6.69 | **20.9** | **26.9** | **25.7** | **25.1** | **24.9** | **22.4** | **15.9** | 7.80 |
| 17 | 2.37 | 8.46 | 7.12 | 7.20 | 7.27 | 10.5 | 9.91 | 9.56 | **22.6** | **23.3** | **24.7** | 6.30 |
| 18 | 4.55 | 5.73 | 5.12 | 6.43 | 5.41 | 5.62 | 5.5 | 9.38 | 14.0 | 12.1 | 11.3 | 11.6 |
| 19 | 2.90 | 2.62 | 2.41 | 8.22 | 4.58 | 3.16 | 4.02 | 5.07 | 4.57 | 4.06 | 3.31 | 2.82 |
| 21 | 3.16 | 3.12 | 3.08 | 2.97 | 13.0 | **20.6** | **18.7** | **16.4** | **16.3** | 14.2 | 6.78 | 3.21 |
| 22 | 2.06 | 2.82 | 5.11 | 5.42 | 6.89 | 12.6 | 7.80 | 7.11 | 6.52 | 6.55 | 7.55 | 7.45 |
| 23 | 8.30 | 9.06 | 11.1 | 13.5 | 13.2 | 12.4 | 11.7 | 11.0 | 9.55 | 7.16 | 5.69 | 5.41 |
| 24 | 4.63 | 6.06 | 6.43 | 5.24 | 5.06 | 4.91 | 5.02 | 8.21 | 11.9 | 12.6 | 11.9 | 12.2 |
| 25 | 4.28 | 4.28 | 4.15 | 4.23 | 6.82 | 10.9 | 11.3 | 10.9 | 10.1 | 9.68 | 9.17 | 8.82 |
| 26 | 3.51 | 3.83 | 3.99 | 3.93 | 3.86 | 3.99 | 4.00 | 4.01 | 4.12 | 4.39 | 4.30 | 4.23 |
| 27 | 8.06 | 9.13 | 9.84 | 10.3 | 10.4 | 11.4 | 13.10 | 13.9 | 14.2 | 13.3 | 12.2 | 10.1 |
| 29 | 13.7 | **35.7** | **18.8** | **17.7** | **16.8** | **16.5** | **16.6** | **15.7** | 14.4 | 14.1 | 13.7 | 13.4 |
| 31 | 4.03 | 5.03 | 5.14 | 6.17 | 13.1 | **15.4** | **15.6** | **16.3** | **20.8** | **18.8** | 7.91 | 4.48 |

| June Sequential Sampling Results by Site/Liter (µg/L) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Liter** | | | | | | | | | | | |
| **Site** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| 32 | 3.08 | 2.29 | 2.07 | 2.28 | 6.95 | 15.5 | 9.91 | 9.27 | 8.30 | 6.12 | 2.60 | 1.65 |
| 33 | 5.18 | 6.85 | 10.0 | 7.74 | 9.61 | 13.9 | **16.4** | 13.5 | 12.3 | 13.7 | 10.7 | 9.95 |
| 35 | 2.86 | 7.89 | 12.9 | 11.9 | 9.85 | 8.59 | 7.28 | 6.82 | 6.23 | 5.34 | 5.02 | 4.83 |
| 36 | 5.02 | 6.90 | 7.68 | 8.46 | 9.90 | 9.81 | 9.51 | 9.34 | 9.19 | 8.93 | 9.20 | 9.19 |
| 38 | 1.92 | 3.04 | 3.06 | 3.04 | 2.91 | 3.03 | 3.12 | 3.07 | 3.36 | 3.21 | 3.04 | 3.76 |
| *Min* | *1.80* | *2.23* | *2.07* | *2.28* | *2.44* | *2.75* | *2.65* | *2.59* | *3.36* | *3.11* | *2.60* | *1.65* |
| *Max* | *13.7* | ***35.7*** | ***24.8*** | ***27.8*** | ***32.0*** | ***33.5*** | ***32.2*** | ***28.9*** | ***32.1*** | ***29.7*** | ***24.7*** | ***20.9*** |
| *Ave* | *4.83* | *7.28* | *8.42* | *9.07* | *11.1* | *13.1* | *12.4* | *11.7* | *12.5* | *11.7* | *10.3* | *8.50* |
| *90th %ile* | *10.4* | *12.8* | ***20.8*** | ***19.7*** | ***20.9*** | ***24.3*** | ***23.6*** | ***21.9*** | ***23.9*** | ***22.4*** | ***21.1*** | ***18.7*** |

**Table S5:** Summary of June Sequential Sampling Results. Samples that were above the lead AL are in bold, and samples that contained visible particulates are shaded yellow.

***Sequential Sampling Results (September and October 2011)*** – The results of the each liter in the sequential sampling conducted in September and October are tabulated below in Table S6 by site. Considerably more sample results contained visible particulates than in previous rounds. The presence of particulates may be a result of the Chicago Fire Department exercising valves during the time period when samples were being collected.

All sites collected at least 11 sequential samples, and some sites with high sample results in June collected additional samples. The additional sequential sample results are included here but were not included in the data analyses, since extra samples were collected only from sites with high lead. A review of the data, including and excluding these additional results was performed to ensure that a bias has not been introduced, and the review indicates that the study findings are not significantly affected by including or excluding the data. With the additional 39 samples included, a total of 80 of 358 sample results (22%) exceeded the lead AL. Using only samples 1 through 11 from each site, a total of 75 of 319 sample results (24%) exceeded the lead AL. For the purpose of the data analyses, the first liter sample from the sequential samples in June and Sept/Oct also serve as the first-draw PF sample.

| Sept/Oct Sequential Sampling Results by Site/Liter (µg/L) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Liter | | | | | | | | | | |
| **Site** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **01** | 9.19 | 12.8 | **21.4** | **22.3** | **22.0** | **19.6** | **16.5** | **15.6** | 14.5 | 14.2 | 13.8 |
| **03** | 8.28 | 5.58 | 5.17 | 6.43 | 8.46 | 14.9 | **19.6** | **16.4** | **15.4** | 14.3 | **17.1** |
| **05** | 2.76 | 10.8 | 12.2 | 10.9 | 12.3 | 7.21 | 5.49 | 5.24 | 4.65 | 5.30 | 5.40 |
| **06** | 2.25 | 2.18 | 3.43 | 2.37 | 2.30 | 2.28 | 2.81 | 2.32 | 2.20 | 4.16 | 5.03 |
| **07** | 4.03 | 4.27 | 5.74 | 5.75 | 9.87 | 15.1 | 15.3 | 15.2 | 12.1 | 14.8 | 13.9 |
| **08** | 9.24 | 8.95 | 9.45 | 11.8 | **18.3** | **25.0** | **22.7** | **22.3** | **22.9** | **19.1** | **15.8** |
| **09** | 8.29 | **20.0** | **18.8** | **21.3** | **20.0** | **17.6** | **16.3** | **15.7** | 14.6 | 14.8 | **16.1** |
| **10** | 3.46 | 6.27 | 6.23 | 5.05 | 14.8 | **21.4** | **33.1** | **29.8** | **32.4** | **28.1** | **27.7** |
| **11** | 2.96 | 4.05 | 3.90 | 3.91 | 4.30 | 4.44 | 4.35 | 4.71 | 5.02 | 4.75 | 4.47 |
| **12** | 5.35 | **15.7** | **16.4** | **19.8** | **23.0** | **30.3** | **25.7** | **22.4** | **19.0** | **17.3** | 12.2 |
| **13** | 1.88 | 7.73 | 9.01 | 3.57 | 2.53 | 3.85 | 2.96 | 2.17 | 2.85 | 7.55 | 5.74 |
| **17** | 2.73 | 2.38 | 5.45 | 4.41 | 4.07 | 4.09 | 3.72 | 3.42 | 3.35 | 3.42 | 3.17 |
| **18** | 4.75 | 5.09 | 4.91 | 5.53 | 4.81 | 8.17 | 8.61 | 8.67 | 11.6 | 11.6 | 11.4 |
| **19** | 3.01 | 3.07 | 2.75 | 3.80 | 3.25 | 3.37 | 5.80 | 6.01 | 6.15 | 5.18 | 3.83 |
| **21** | 2.99 | 3.35 | 3.03 | 3.04 | **16.8** | **18.2** | **16.1** | 13.2 | 14.9 | 15.0 | 5.24 |
| **22** | 2.29 | 2.86 | 5.60 | 5.39 | 6.32 | 8.49 | 7.42 | 7.20 | 6.64 | 7.09 | 7.36 |
| **23** | 7.02 | 8.00 | 8.99 | 11.0 | 12.5 | 12.1 | 12.8 | 11.8 | 10.5 | 12.1 | 10.1 |
| **24** | 6.62 | 8.84 | 7.30 | 6.38 | 6.45 | 6.59 | 6.82 | 10.6 | 14.5 | 13.2 | 12.8 |
| **26** | 4.88 | 4.61 | 4.52 | 4.46 | 4.52 | 4.26 | 5.18 | 5.40 | 5.94 | 5.72 | 5.82 |
| **27** | 12.6 | 12.4 | 12.2 | 12.5 | 12.5 | 13.1 | **16.3** | **18.0** | **18.9** | **19.6** | **17.3** |
| **28** | 3.94 | 5.58 | 5.39 | 5.32 | 5.39 | 5.11 | 5.73 | 5.65 | 5.30 | 5.49 | 5.55 |
| **29** | **17.6** | **36.7** | **18.3** | **17.3** | **16.6** | **15.9** | **15.9** | 14.3 | **16.2** | 12.8 | 13.2 |
| **30** | 7.88 | 7.46 | 8.67 | 9.54 | 9.09 | 11.0 | 12.9 | **22.9** | **31.3** | **31.8** | **33.1** |
| **31** | 5.97 | 5.82 | 5.20 | 6.72 | 15.6 | 13.4 | **17.3** | **18.5** | **23.9** | **16.3** | 5.70 |
| **32** | 2.94 | 2.24 | 2.03 | 2.22 | 5.50 | **17.3** | 9.42 | 9.07 | 8.63 | 7.64 | 3.50 |
| **33** | 5.52 | 6.26 | 12.8 | 9.09 | 12.0 | 14.1 | **21.6** | **16.6** | **16.5** | **15.8** | 14.1 |
| **34** | 1.52 | 1.72 | 1.69 | 1.62 | 1.73 | 2.66 | 2.91 | 2.87 | 3.17 | 2.10 | 1.90 |
| **35** | 3.44 | 7.42 | 14.6 | **18.9** | **16.0** | 12.5 | 10.1 | 9.56 | 7.60 | 8.18 | 7.21 |
| **36** | 4.61 | 5.01 | 5.51 | 6.11 | 13.0 | 11.6 | 10.3 | 10.4 | 10.9 | 10.3 | 9.93 |
| **Min** | *1.52* | *1.72* | *1.69* | *1.62* | *1.73* | *2.28* | *2.81* | *2.17* | *2.20* | *2.10* | *1.90* |
| **Max** | ***17.6*** | ***36.7*** | ***21.4*** | ***22.3*** | ***23.0*** | ***30.3*** | ***33.1*** | ***29.8*** | ***32.4*** | ***31.8*** | ***33.1*** |
| **Ave** | *5.45* | *7.83* | *8.30* | *8.50* | *10.5* | *11.9* | *12.2* | *12.0* | *12.5* | *12.0* | *10.6* |
| **$90^{th}$ %ile** | *9.19* | *12.8* | ***16.4*** | ***18.9*** | ***18.3*** | ***19.6*** | ***21.6*** | ***22.3*** | ***22.9*** | ***19.1*** | ***17.1*** |

**Table S6a:** Summary of September/October sequential sampling results used in data analyses. Samples that were above the lead AL are in bold, and samples that contained visible particulates are shaded yellow.

| Sept/Oct Sequential Sampling Results by Site/Liter (µg/L) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Liter | | | | | | | | |
| **Site** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **01** | 13.9 | 14.1 | 11.7 | -- | -- | -- | -- | -- | -- |
| **03** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **05** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **06** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **07** | 12.7 | 9.29 | 6.52 | 6.03 | -- | -- | -- | -- | -- |
| **08** | 12.8 | 9.34 | 7.93 | 6.27 | -- | -- | -- | -- | -- |
| **09** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **10** | -- | **27.1** | **21.1** | 10.7 | -- | -- | -- | -- | -- |
| **11** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **12** | 6.98 | 3.28 | 2.04 | -- | -- | -- | -- | -- | -- |
| **13** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **17** | 2.84 | 2.62 | 2.59 | -- | -- | -- | -- | -- | -- |
| **18** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **19** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **21** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **22** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **23** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **24** | 12.8 | 15.3 | 15.4 | -- | -- | -- | -- | -- | -- |
| **26** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **27** | **16.0** | 12.8 | 9.24 | -- | -- | -- | -- | -- | -- |
| **28** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **29** | 11.1 | 10.1 | 9.21 | 9.01 | 9.29 | 8.99 | 8.77 | 8.73 | 8.39 |
| **30** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **31** | 4.17 | -- | -- | -- | -- | -- | -- | -- | -- |
| **32** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **33** | 12.4 | 11.5 | 10.1 | -- | -- | -- | -- | -- | -- |
| **34** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **35** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **36** | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **Min** | *2.84* | *2.62* | *2.04* | *6.03* | *9.29* | *8.99* | *8.77* | *8.73* | *8.39* |
| **Max** | ***16.0*** | ***27.1*** | ***21.1*** | *10.7* | *9.29* | *8.99* | *8.77* | *8.73* | *8.39* |
| **Ave** | *10.6* | *11.5* | *9.58* | *8.00* | *9.29* | *8.99* | *8.77* | *8.73* | *8.39* |
| **$90^{th}$ %ile** | *13.9* | *15.3* | *15.4* | *10.7* | *9.29* | *8.99* | *8.77* | *8.73* | *8.39* |

**Table S6b:** Summary of Supplemental September/October sequential sampling results not used in data analyses. Samples that were above the lead AL are in bold, and samples that contained visible particulates are shaded yellow.

***Stagnation Times*** – Volunteers were asked to record the date and time water was last used, and the date and time when sampling began for each set of samples. Table S6c is a summary table which contains the stagnation times for the sequential samples, which is the amount of time the water sat motionless in the household prior to sample collection.

| **Sample Collection Stagnation Times** | | | |
|---|---|---|---|
| June Sequential Sampling | | Sept/Oct Sequential Sampling | |
| Site | Stagnation Time (hrs:mins) | Site | Stagnation Time (hrs:mins) |
| 1 | 6:32 | 1 | 8:04 |
| 3 | 7:13 | 3 | 7:45 |
| 4 | 7:06 | 5 | 7:45 |
| 5 | 7:00 | 6 | 8:00 |
| 6 | 9:10 | 7 | 7:13 |
| 7 | 7:24 | 8 | 6:05 |
| 8 | 7:35 | 9 | 7:20 |
| 9 | 8:15 | 10 | *** |
| 10 | 6:06 | 11 | 7:08 |
| 11 | 7:00 | 12 | 6:26 |
| 12 | 8:06 | 13 | *** |
| 17 | 6:25 | 17 | 6:55 |
| 18 | 8:43 | 18 | 12:53 |
| 19 | 6:30 | 19 | *** |
| 21 | 6:15 | 21 | 6:00 |
| 22 | 6:20 | 22 | 6:15 |
| 23 | 7:45 | 23 | 9:00 |
| 24 | 8:33 | 24 | 7:01 |
| 25 | 8:32 | 26 | 7:00 |
| 26 | 7:00 | 27 | 7:45 |
| 27 | 7:00 | 28 | 8:00 |
| 29 | *** | 29 | *** |
| 31 | 7:26 | 30 | 10:45 |
| 32 | 7:13 | 31 | 7:30 |
| 33 | 7:02 | 32 | 6:54 |
| 35 | 7:04 | 33 | 9:06 |
| 36 | 7:45 | 34 | 7:05 |
| 38 | 7:13 | 35 | 6:55 |
| | | 36 | 8:47 |
| ***Volunteer did not record date/time the water was last used, but said it was the day before and was at least 6 hours before sampling. | | | |

**Table S6c:** Summary of stagnation times for sequential sampling.

***Seasonal Variability*** – Table S6d contains a site by site comparison of lead concentrations.

| Seasonal Variability (Spring vs. Fall & Summer vs. Fall) | | | | | |
|---|---|---|---|---|---|
| First-Draw NHU | Sept/Oct > Mar/Apr | First-Draw PF | Sept/Oct > Mar/Apr | Sequential Samples | Sept/Oct > June |
| No. of Sample Pairs | 28 | No. of Sample Pairs | 29 | No. of Sample Pairs | 285 |
| No. Higher in Sept/Oct | 19 | No. Higher in Sept/Oct | 20 | No. Higher in Sept/Oct | 156 |
| % Higher in Sept/Oct | 68% | % Higher in Sept/Oct | 69% | % Higher in Sept/Oct | 55% |
| First-Draw Samples: Mar/Apr vs. Sept/Oct (Same Site, Same First-Draw Protocol Compared) | | | | | |
| Sequential Samples: June vs. Sept/Oct (Same Site/Same Liter Compared) | | | | | |

**Table S6d:** Seasonal variability effects observed.

***Flushed sample results*** – The results of the flushed samples collected in September and October are tabulated in Table S7 by site. Most sites collected a 3 minute and 5 minute flushed sample. Some sites collected a 3, 5, and 7 minute flushed sample; and one site (site 29) collected a 3, 5, and 10 minute flushed sample, due to the length of the service line (159 ft / 48.5 m).

A flushed sample is collected by fully opening the sample tap and letting the water run for at least five minutes prior to a minimum 6 hour stagnation period. The date and time of the PF was recorded. After the minimum 6 hour stagnation period, and immediately before beginning the flushed sample collection, the date and time were again recorded and used as the start of sampling. The 3, 5, 7 and 10 minutes are measured from that start time, and water was not turned off between samples. For sequential sampling and flushed samples, the water was not turned off between samples.

EPA's current Public Notification Handbook includes instructions that advise residents to run the water between 30 and 45 seconds before collecting water for consumption if the water has not been used for an extended period of time. Running the water (flushing) for 45 seconds resulted in high lead levels at the tap for some sites. The flushed sampling results in this study indicate that EPA should develop a more appropriate flushing guidance, based on whether a home has a LSL or not, and the length of the LSL.

For homes with long LSLs, such as Site 29 (159 ft / 48.5 m), flushing may not be a practical way to reduce lead levels, as lead levels did not decline any further following 3, 5 and 10 minutes of flushing. In the case of site 29, residents would likely have a minimum of approximately 8 to 11 μg/L of lead in the drinking water for all water consumed, and should consider installing a water filter or using bottled water for drinking and cooking.

| Flushed Sample Summary Table (µg/L) | | | | | | |
|---|---|---|---|---|---|---|
| | Mar/Apr 2011 | Mar/Apr 2011 | Sept/Oct 2011 | Sept/Oct 2011 | Sept/Oct 2011 | Sept/Oct 2011 |
| **Site** | **NHU 45sec** | **PF 45sec** | **3min** | **5min** | **7min** | **10min** |
| **01** | 11.3 | 11.9 | 6.48 | 6.56 | 6.97 | |
| **03** | 12.0 | 6.71 | 3.78 | 2.93 | | |
| **04** | 6.76 | 2.56 | | | | |
| **05** | 13.2 | 14.1 | | | | |
| **06** | 1.90 | 2.13 | | | | |
| **07** | **15.3** | **24.9** | 5.49 | 5.46 | 5.32 | |
| **08** | **32.2** | **28.0** | 8.25 | 5.54 | 5.71 | |
| **09** | **15.9** | **17.7** | 14.3 | 7.23 | | |
| **10** | **25.0** | **21.6** | 4.95 | 4.30 | 4.09 | |
| **11** | 4.13 | 5.30 | 1.75 | 1.69 | | |
| **12** | **17.2** | 5.45 | 1.78 | 1.45 | 1.33 | |
| **13** | 3.50 | 2.94 | | | | |
| **17** | 4.00 | 3.70 | 2.88 | 2.76 | 2.86 | |
| **18** | 9.57 | 12.4 | 4.15 | 3.71 | | |
| **19** | 4.69 | 8.27 | | | | |
| **20** | 2.80 | 2.54 | | | | |
| **21** | 6.87 | 13.8 | | | | |
| **22** | 9.19 | 7.93 | | | | |
| **23** | 13.1 | 11.5 | 5.64 | 4.54 | | |
| **24** | 6.10 | 4.98 | 6.38 | 12.4 | | |
| **25** | 3.75 | ND | | | | |
| **26** | 3.02 | 3.45 | 5.06 | 3.23 | | |
| **27** | 4.53 | 3.76 | 15.0 | 14.1 | | |
| **28** | 4.99 | 4.70 | 4.82 | 3.26 | | |
| **29** | 13.5 | **28.6** | 11.9 | 10.9 | | 10.8 |
| **30** | 12.5 | 6.52 | 5.80 | 4.82 | | |
| **31** | 3.16 | 12.3 | 3.78 | 3.76 | | |
| **32** | 2.29 | 7.82 | | | | |
| **33** | **16.4** | 14.0 | 4.40 | 4.06 | | |
| **34** | 1.51 | 3.30 | 1.83 | 1.75 | | |
| **35** | 5.28 | 10.5 | 5.53 | 4.03 | | |
| **36** | 11.1 | 8.76 | 7.19 | 5.29 | | |
| **38** | 1.60 | 2.30 | | | | |

NHU 45sec Samples were collected following the collection of the First-Draw NHU samples by running the water for 45 seconds following the collection of the First-Draw NHU sample.

PF 45sec Samples were collected following the collection of the First-Draw PF samples by running the water for 45 seconds following the collection of the First-Draw PF sample.

3min, 5min, 7min, and 10min flushed samples were collected after pre-flushing the tap for at least 5 minutes prior to the minimum 6 hour stagnation time during which no water was used in the home. Following the stagnation period and prior to sample collection, residents flushed the tap for 3 min to collect the 3min sample, and then an additional 2min for the 5min sample or 4min for the 7min sample. One site (site 29) had the longest lead service line so this site collected a 3 min, 5 min and 10min flushed sample (water was flushed for an additional 5 minutes following the collection of the 5min sample to collect the 10 min flushed sample). Water was not turned off in between samples to avoid the water hammer effect. Residents were instructed to have the bottles ready to insert under the faucet at the appropriate time.

Site 20 and Site 21 are the same residence. Site 20 was the upstairs bathroom and Site 21 was the kitchen sink. Note that neither the 45sec NHU nor PF samples from the upstairs tap captured any LSL water, while at least one of the kitchen tap samples did.

**Table S7:** Summary table of flushed sample results. Samples that were above the lead AL are in bold, and samples that contained visible particulates are shaded yellow.

***Classification of Disturbed LSL Sites*** – A summary of the classification of each site as "disturbed", "undisturbed", or "indeterminate" is presented in Table S8, along with the number of samples collected per site and the number and percentage of sample results above the lead action level. The results from the "disturbed" and "undisturbed" sites are consistent with other research efforts showing that LSL disturbances result in higher lead levels[1-3].

| **Disturbed, Undisturbed and Indeterminate Site Summary** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Disturbed Sites | Total Samples Collected | # Samples Above AL (Disturbed) | Undisturbed Sites | Total Samples Collected | # Samples above AL (Undisturbed) | Indeterminate Sites | Total Samples Collected | # Samples above AL (Indeterminate) |
| 01 | 27 | 16 | 03 | 27 | 4 | 12 | 27 | 17 |
| 05 | 27 | 2 | 04 | 14 | 0 | 21 | 27 | 7 |
| 07 | 27 | 11 | 06 | 27 | 0 | 33 | 27 | 6 |
| 08 | 27 | 19 | 11 | 27 | 0 | --- | --- | --- |
| 09 | 27 | 15 | 13 | 15 | 0 | --- | --- | --- |
| 10 | 27 | 15 | 18 | 27 | 0 | --- | --- | --- |
| 17 | 27 | 3 | 19 | 27 | 0 | --- | --- | --- |
| 27 | 27 | 5 | 22 | 27 | 0 | --- | --- | --- |
| 28 | 15 | 0 | 23 | 27 | 0 | --- | --- | --- |
| 29 | 27 | 15 | 24 | 27 | 0 | --- | --- | --- |
| 30 | 15 | 4 | 25 | 14 | 0 | --- | --- | --- |
| 31 | 27 | 10 | 26 | 27 | 0 | --- | --- | --- |
| 35 | 27 | 2 | 32 | 27 | 2 | --- | --- | --- |
| --- | --- | --- | 34 | 15 | 0 | --- | --- | --- |
| --- | --- | --- | 36 | 27 | 0 | --- | --- | --- |
| --- | --- | --- | 38 | 16 | 0 | --- | --- | --- |
| **Totals** | **327** | **117** | **Totals** | **371** | **6** | **Totals** | **81** | **30** |
| **% of samples above AL:** | | **36%** | **% of samples above AL:** | | **2%** | **% of samples above AL:** | | **37%** |

**Table S8:** Summary Table of Disturbed, Undisturbed and Indeterminate Sites, with the number and percentages of sample results above the lead AL for each site and each grouping.

Many direct LSL disturbances are localized to a specific segment of the LSL, and yet some sites have higher lead levels in sample liters over a significant portion of the LSL, not just in the immediate area of the LSL that was disturbed. A probable reason is that, except for the initial liter of water, each subsequent one-liter sample reflects both lead levels within the segment of the plumbing where the water stagnated as well as a contribution from the rest of the plumbing the water travelled through. For example, the fifth liter of water collected from a kitchen tap will not only capture the lead from the segment of LSL where the water stagnated, but it will also collect contributions from the plumbing downstream as the water passes through the remaining LSL and internal plumbing on the way to the kitchen tap. If the sample results only represented the portion of the plumbing where the water stagnated, it would be expected that a variety of metals would be found in the initial liters due to the presence of a variety of metallic plumbing materials and components, but only lead should be found in the LSL samples. In this study, a variety of metals was detected even in samples that represented LSL samples (Figure S6).

Specifically, for Site 9, information provided by the resident indicated that the internal pipe from the LSL to the kitchen tap was galvanized iron pipe. This was confirmed by the co-occurrence of higher levels of zinc and iron within the first liter of water in figure S6. There were no copper pipes in the home, so the presence of the copper is indicative of brass components (faucet, connectors, shut-off valve(s), and the water meter). Trace amounts of iron, zinc and copper are captured in the later liter samples as the water flows through the internal plumbing en route to the kitchen tap, along with traces of iron, potentially from the water main. It can reasonably be assumed that the same phenomenon occurred for lead. Disturbed areas of the LSL have damaged scale, which can expose water passing through them to fresh lead. Therefore, lead measured in any sample upstream of the damaged area may include lead contributions from the damaged area.

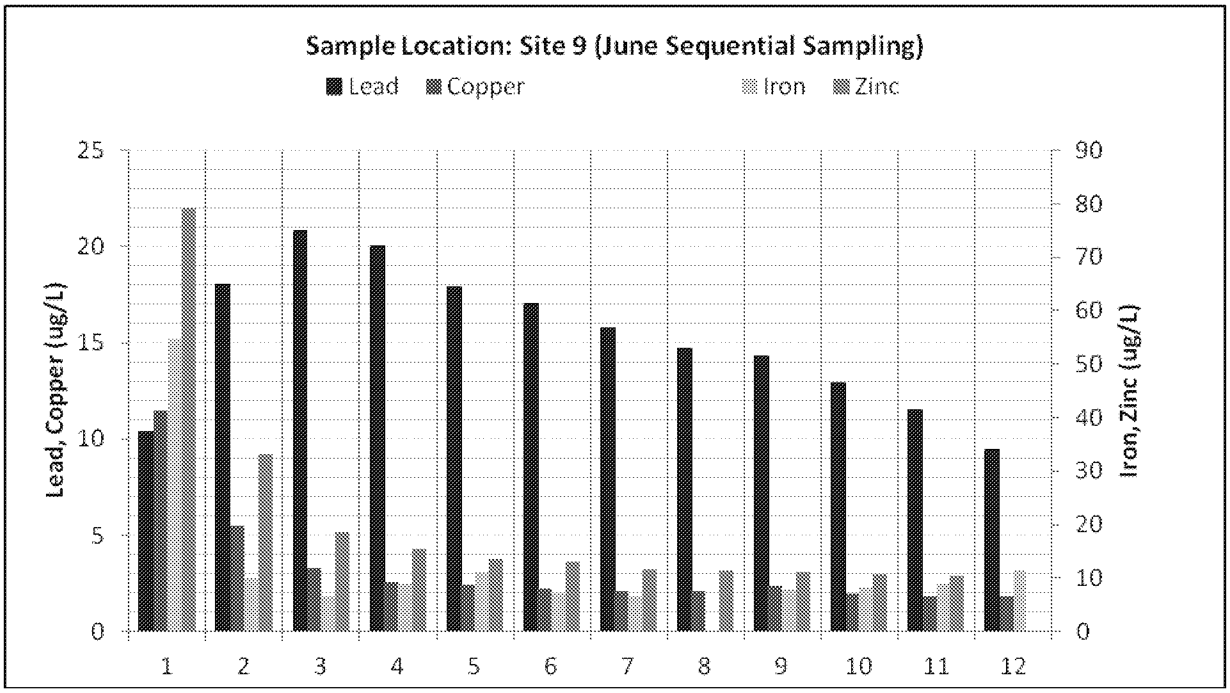



**Figure S6:** The LSL at Site 9 measures approximately 102 ft (31.1 m) from the water main to the meter. From the meter, there is approximately 13.5 ft (4.1 m) of 1 inch (2.54 cm) galvanized pipe to the kitchen tap.

***Variability of lead levels in City B*** – A second city, City B, exceeded the lead AL during the July-Dec 2010 monitoring period, and was required to comply with the LSL replacement requirements in the LCR. Table S9 contains the compliance monitoring history for City B.

| Monitoring Period Begin Date | Monitoring Period End Date | Number of Samples | Lead 90$^{th}$ Percentile Value (µg/l) |
|---|---|---|---|
| 7/1/2011 | 12/31/2011 | 101 | 12 |
| 1/1/2011 | 6/30/2011 | 130 | 14 |
| 7/1/2010 | 12/31/2010 | 105 | **23** |
| 1/1/2009 | 12/31/2009 | 51 | 15 |
| 1/1/2008 | 12/31/2008 | 58 | 14 |
| 1/1/2007 | 12/31/2007 | 50 | 11 |
| 1/1/2006 | 12/31/2006 | 60 | 14 |
| 1/1/2005 | 12/31/2005 | 54 | 13 |
| 1/1/2004 | 6/30/2004 | 104 | 12 |
| 7/1/2003 | 12/31/2003 | 108 | 12 |
| 1/1/2002 | 12/31/2004 | 50 | 15 |
| 1/1/1999 | 12/31/1999 | 55 | 14 |
| 1/1/1998 | 12/31/1998 | 50 | 6 |
| 1/1/1997 | 12/31/1997 | 50 | 7 |
| 7/1/1996 | 12/31/1996 | 50 | 15 |
| 1/1/1996 | 6/30/1996 | 50 | 15 |
| 7/1/1992 | 12/31/1992 | 50 | 15 |
| 1/1/1992 | 6/30/1992 | 50 | **21** |

**Table S9:** City B 90$^{th}$ percentile compliance values (1992 – 2012). Samples that were above the lead AL are in bold.

The sampling instructions presented in Figure S7 are in accordance with the LCR, and were used to collect the LSL samples in City B, which has approximately 25,000 LSLs.

**Instructions for Lead Sample Collection**

1 Make sure the faucet used for sample collection is NOT attached to a water softener or any filtering device.

2 At bedtime, make sure the following rule is followed:
  - The water for the entire house, not just the faucet that is being used for collection, remains undisturbed for a period of at least six hours.
    - **No** faucets in the house are used, which includes the bath tub, shower and sinks.
    - The toilet is **not** flushed during this time period.
    - The water is **not** run for an ice maker.

3 When you are ready to collect the sample:
  - Make sure the sample is taken before any other water is used.
    - Open the collection container.
    - Turn on the **cold** water.
    - Allow the water to run until there is a significant change in temperature.
    - Fill the container to the shoulder.
    - Do **not** rinse the bottle out.
    - Immediately cap the sample container.

4 Fill out the enclosed chain of custody form and survey.

5 Fold and secure the chain of custody form and survey with a rubber band around the outside of the sample container.
  - Place the container outside where it was delivered.

❖ A city utilities employee will pick up the sample container. No one will enter your home. The sample must be left outside to be picked up.

**Figure S7:** LSL sampling instructions provided by City B to residents.

The sampling protocol used for collecting LSL samples ("allow the water to run until there is a significant change in temperature") can result in some sample results reflecting lead levels from internal plumbing rather than from within the LSLs.

The results from City B are presented below in Figure S8. Similar to the results presented for the study of Chicago, City B's results show significant variability in LSL lead levels across the system. Following the 2010 lead AL exceedance, the City B took 1,975 LSL samples, with a total of 1,762 results (89%) below the lead AL and 213 results (11%) above the lead AL. LSL results above the AL were significantly variable, ranging from 16 μg/L to 580 μg/L with a large number of sample results in exceedance of 50 μg/L.

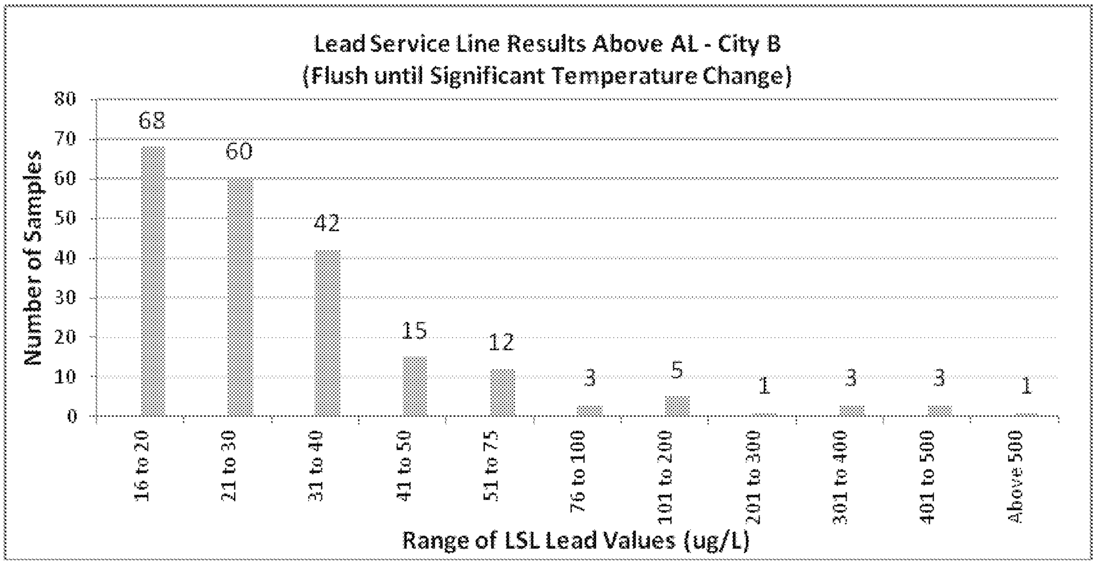
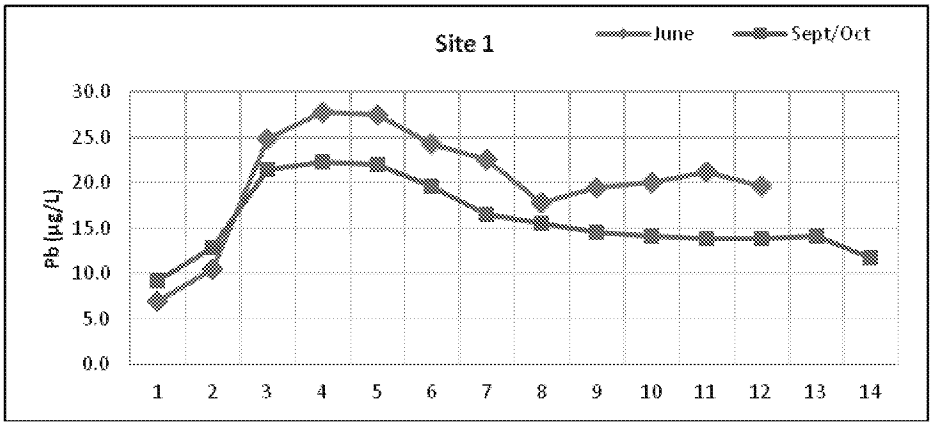



**Figure S8:** Range of lead values for City B LSL sampling results

***Sequential Sampling Summary Graphs*** –The headers are color-coded based on whether the site has a disturbed LSL (red) or an undisturbed LSL (green). Sites for which this could not be determined (indeterminate sites) are color-coded orange. Water usage information is listed for each site. The samples which contained visible particulates are highlighted yellow, and the results that are above the lead AL are in bold text in the data tables. For sites that conducted sequential sampling in both June and Sept/Oct, the sequential sampling profiles were generally consistent during both sampling periods (see Figures S9 – S40).

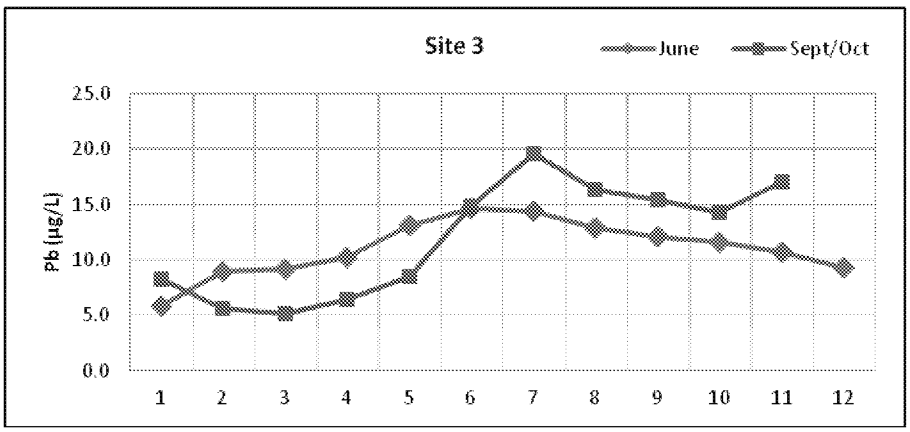
| Site 1 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 7.0 | 9.2 |
| 2 | 11 | 13 |
| 3 | **25** | **21** |
| 4 | **28** | **22** |
| 5 | **28** | **22** |
| 6 | **24** | **20** |
| 7 | **23** | **17** |
| 8 | **18** | **16** |
| 9 | **20** | 15 |
| 10 | **20** | 14 |
| 11 | **21** | 14 |
| 12 | **20** | 14 |
| 13 | | 14 |
| 14 | | 12 |




Disturbance(s): Water meter installed in 2010
Approximate LSL Length: 89 ft (27.1 m)
Ave Monthly Water Use: 3,444 gal. (13,037 L)

**Figure S9:** Sequential Lead Results - Sample Site #1 (June and Sept/Oct)

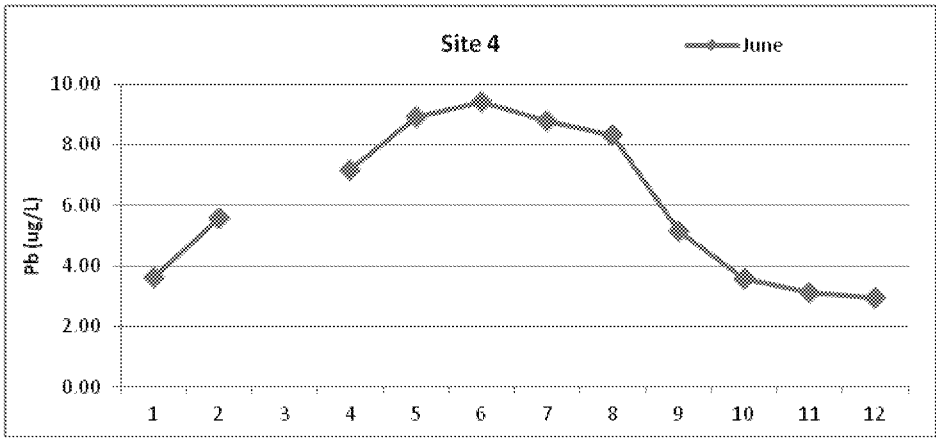
| Site 3 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 5.8 | 8.3 |
| 2 | 8.9 | 5.6 |
| 3 | 9.2 | 5.2 |
| 4 | 10 | 6.4 |
| 5 | 13 | 8.5 |
| 6 | 15 | 15 |
| 7 | 14 | **20** |
| 8 | 13 | **16** |
| 9 | 12 | 15 |
| 10 | 12 | 14 |
| 11 | 11 | **17** |
| 12 | 9.3 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 73 ft (22.3 m)
Ave Monthly Water Use: Not metered

**Figure S10:** Sequential Lead Results - Sample Site #3 (June and Sept/Oct)

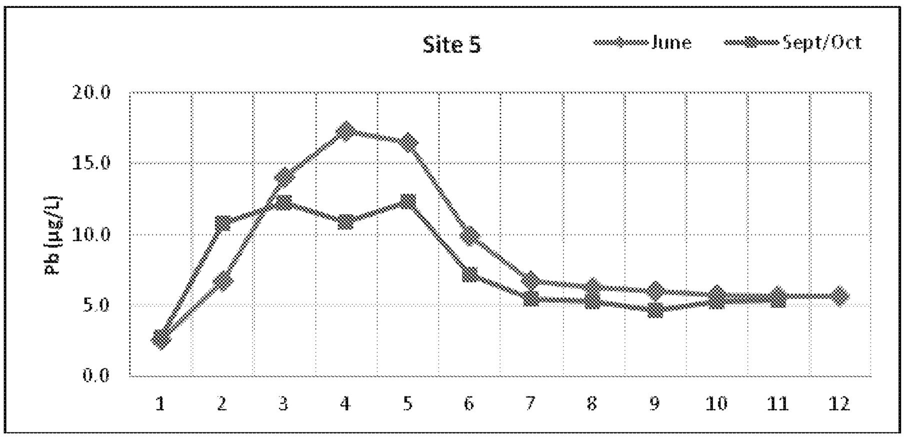
| Site 4 | |
|---|---|
| Liter | June |
| 1 | 3.61 |
| 2 | 5.56 |
| 3 | |
| 4 | 7.17 |
| 5 | 8.90 |
| 6 | 9.41 |
| 7 | 8.78 |
| 8 | 8.30 |
| 9 | 5.14 |
| 10 | 3.59 |
| 11 | 3.11 |
| 12 | 2.96 |




Disturbance(s): No known disturbance
Approximate LSL Length: Unknown
Ave Monthly Water Use: Not metered

**Figure S11:** Sequential Lead Results - Sample Site #4 (June)

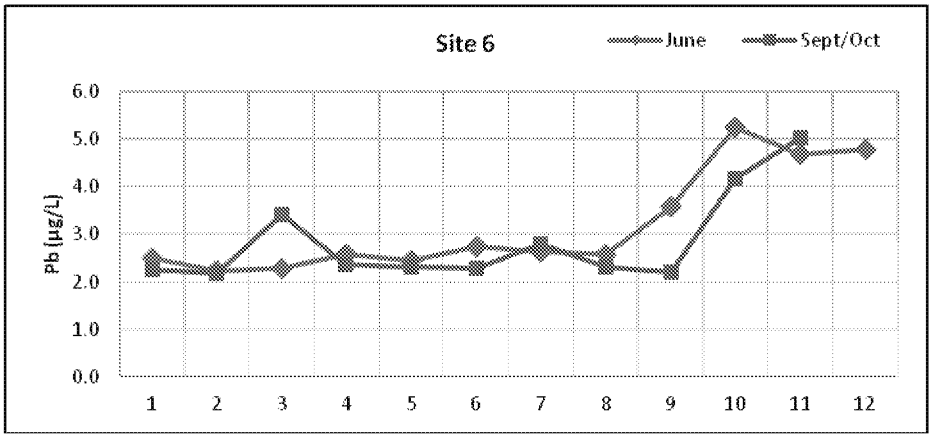
| Site 5 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.6 | 2.8 |
| 2 | 6.7 | 11 |
| 3 | 14 | 12 |
| 4 | **17** | 11 |
| 5 | **17** | 12 |
| 6 | 9.9 | 7.2 |
| 7 | 6.7 | 5.5 |
| 8 | 6.3 | 5.2 |
| 9 | 6.0 | 4.7 |
| 10 | 5.7 | 5.3 |
| 11 | 5.7 | 5.4 |
| 12 | 5.6 | |




Disturbance(s): Water meter installed in 2011
Approximate LSL Length: 80 ft (24.4 m)
Ave Monthly Water Use: 10,400 gal. (39,368 L)

**Figure S12:** Sequential Lead Results - Sample Site #5 (June and Sept/Oct)

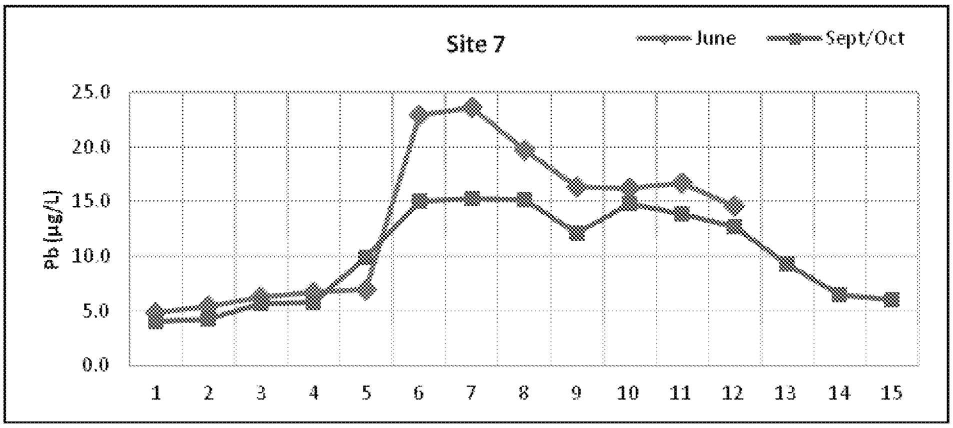
| Site 6 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.5 | 2.3 |
| 2 | 2.2 | 2.2 |
| 3 | 2.3 | 3.4 |
| 4 | 2.6 | 2.4 |
| 5 | 2.4 | 2.3 |
| 6 | 2.8 | 2.3 |
| 7 | 2.7 | 2.8 |
| 8 | 2.6 | 2.3 |
| 9 | 3.6 | 2.2 |
| 10 | 5.3 | 4.2 |
| 11 | 4.7 | 5.0 |
| 12 | 4.8 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 60 ft (18.3 m)
Ave Monthly Water Use: Not metered

**Figure S13:** Sequential Lead Results - Sample Site #6 (June and Sept/Oct)

| Site 7 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 4.9 | 4.0 |
| 2 | 5.5 | 4.3 |
| 3 | 6.3 | 5.7 |
| 4 | 6.7 | 5.8 |
| 5 | 7.0 | 9.9 |
| 6 | **23** | 15 |
| 7 | **24** | 15 |
| 8 | **20** | 15 |
| 9 | **16** | 12 |
| 10 | **16** | 15 |
| 11 | **17** | 14 |
| 12 | 15 | 13 |
| 13 | | 9.3 |
| 14 | | 6.5 |
| 15 | | 6.0 |




Disturbance(s): Street excavation, potential installation of Cu whip at service connection in 2008
Approximate LSL Length: 59+ ft (18.0+ m)
Ave Monthly Water Use: Not metered

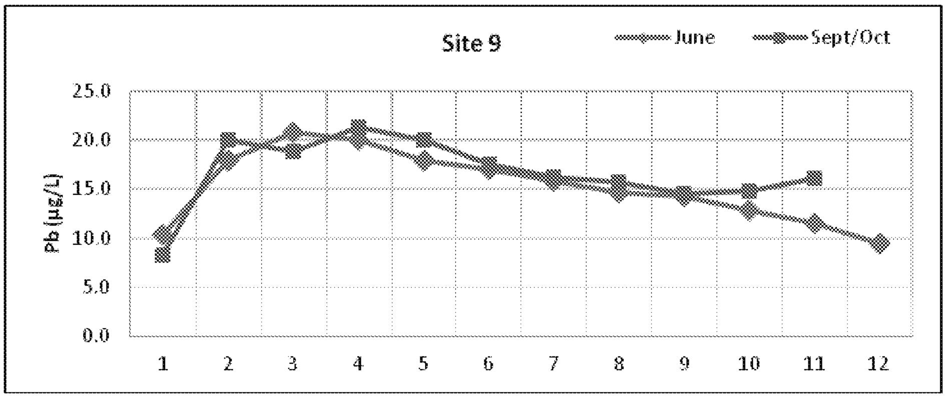
**Figure S14:** Sequential Lead Results - Sample Site #7 (June and Sept/Oct)

| Site 8 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 11 | 9.2 |
| 2 | 13 | 9.0 |
| 3 | **22** | 10 |
| 4 | **20** | 12 |
| 5 | **32** | **18** |
| 6 | **34** | **25** |
| 7 | **32** | **23** |
| 8 | **29** | **22** |
| 9 | **32** | **23** |
| 10 | **30** | **19** |
| 11 | **24** | **16** |
| 12 | **19** | 13 |
| 13 | | 9.3 |
| 14 | | 7.9 |
| 15 | | 6.3 |


Disturbance(s): Leak in parkway, repaired roundway in 2005.
Approximate LSL Length: 57 ft (17.4 m)
Ave Monthly Water Use: Not metered

**Figure S15:** Sequential Lead Results - Sample Site #8 (June and Sept/Oct)

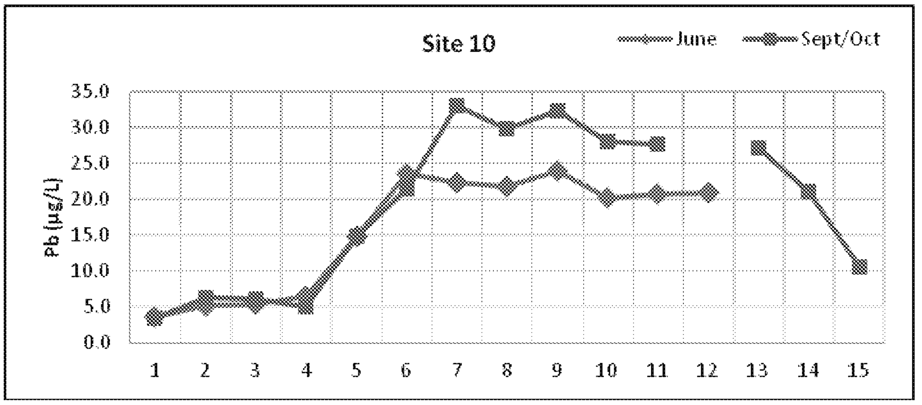
| Site 9 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 10 | 8.3 |
| 2 | **18** | **20** |
| 3 | **21** | **19** |
| 4 | **20** | **21** |
| 5 | **18** | **20** |
| 6 | **17** | **18** |
| 7 | **16** | **16** |
| 8 | 15 | **16** |
| 9 | 14 | 15 |
| 10 | 13 | 15 |
| 11 | 12 | **16** |
| 12 | 10 | |




Disturbance(s): Water meter installed in 2008.
Approximate LSL Length: 102 ft (31.1 m)
Ave Monthly Water Use: 3,190 (12,075 L) – In Sept 2011, usage was 24,000 gal. (90,850 L) due to hose left running for one or more days. In calculating the overall average, the Sept 2010 value of 8,000 gal. (30,283 L) was also used for Sept 2011 instead of the 24,000 gal. (90,850 L) value.

**Figure S16:** Sequential Lead Results - Sample Site #9 (June and Sept/Oct)

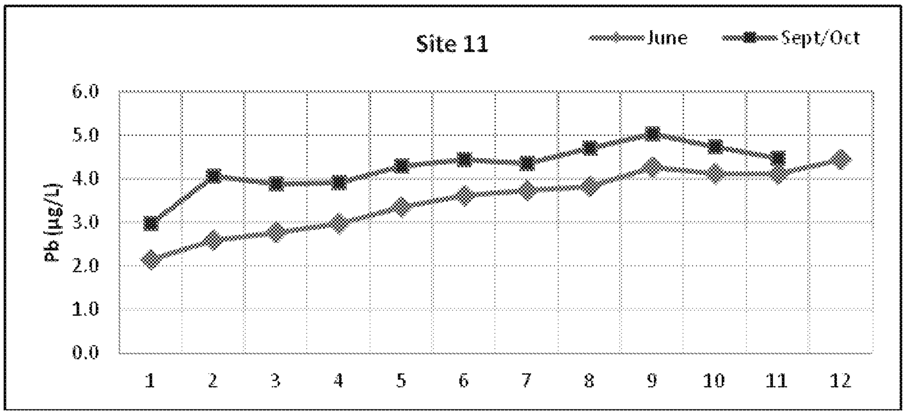
| Site 10 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 3.7 | 3.5 |
| 2 | 5.2 | 6.3 |
| 3 | 5.4 | 6.2 |
| 4 | 6.5 | 5.1 |
| 5 | 15 | 15 |
| 6 | **24** | **21** |
| 7 | **22** | **33** |
| 8 | **22** | **30** |
| 9 | **24** | **32** |
| 10 | **20** | **28** |
| 11 | **21** | **28** |
| 12 | **21** | |
| 13 | | **27** |
| 14 | | **21** |
| 15 | | 11 |




Disturbance(s): Service leak repair, water meter installed in 2009.
Approximate LSL Length: 48+ ft (14.6 m)
Ave Monthly Water Use: 1,826 gal. (6,912 L)

**Figure S17:** Sequential Lead Results - Sample Site #10 (June and Sept/Oct)

| Site 11 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.2 | 3.0 |
| 2 | 2.6 | 4.1 |
| 3 | 2.8 | 3.9 |
| 4 | 3.0 | 3.9 |
| 5 | 3.4 | 4.3 |
| 6 | 3.6 | 4.4 |
| 7 | 3.7 | 4.4 |
| 8 | 3.8 | 4.7 |
| 9 | 4.3 | 5.0 |
| 10 | 4.1 | 4.8 |
| 11 | 4.1 | 4.5 |
| 12 | 4.4 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 50 ft (15.2 m)
Ave Monthly Water Use: Not metered

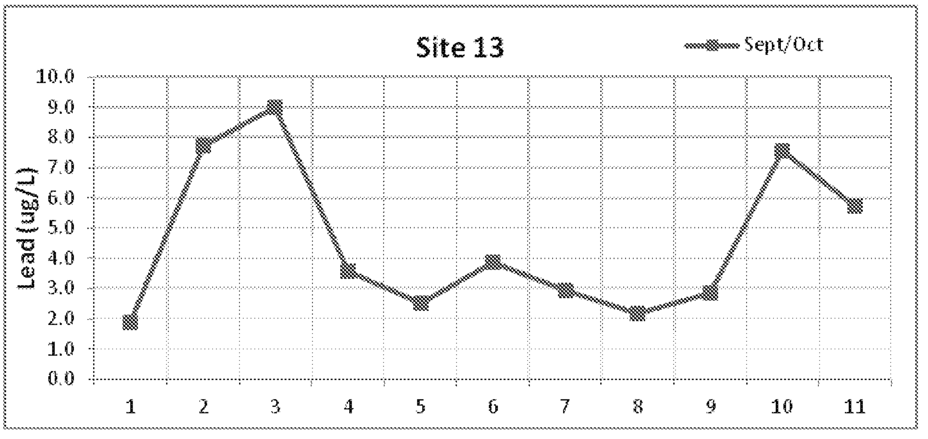
**Figure S18:** Sequential Lead Results - Sample Site #11 (June and Sept/Oct)

| Site 12 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 1.8 | 5.4 |
| 2 | 3.0 | **16** |
| 3 | 3.6 | **16** |
| 4 | 6.7 | **20** |
| 5 | **21** | **23** |
| 6 | **27** | **30** |
| 7 | **26** | **26** |
| 8 | **25** | **22** |
| 9 | **25** | **19** |
| 10 | **22** | **17** |
| 11 | **16** | 12 |
| 12 | 7.8 | 7.0 |
| 13 | | 3.3 |
| 14 | | 2.0 |


Disturbance(s): Indeterminate
Approximate LSL Length: 53 (16.2 m)
Ave Monthly Water Use: Not metered

**Figure S19:** Sequential Lead Results - Sample Site #12 (June and Sept/Oct)

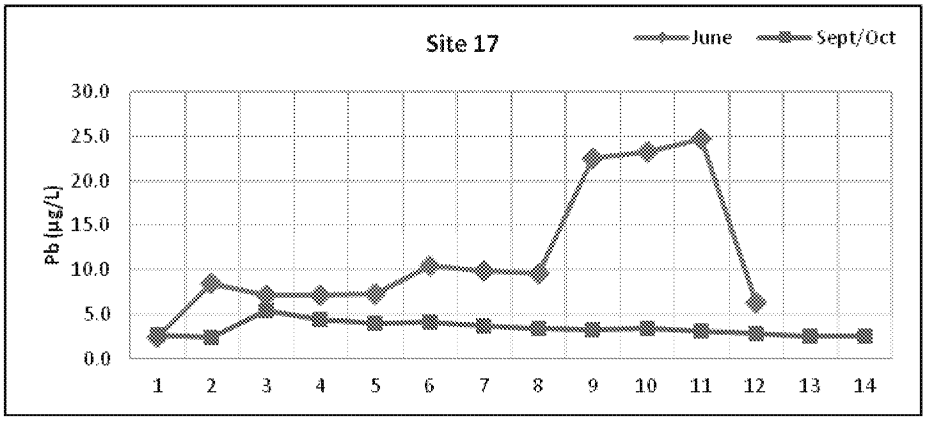
| Site 13 | |
|---|---|
| Liter | Sept/Oct |
| 1 | 1.9 |
| 2 | 7.7 |
| 3 | 9.0 |
| 4 | 3.6 |
| 5 | 2.5 |
| 6 | 3.9 |
| 7 | 3.0 |
| 8 | 2.2 |
| 9 | 2.9 |
| 10 | 7.6 |
| 11 | 5.7 |




Disturbance(s): No known disturbance
Approximate LSL Length: 49+ ft (4.9 m)
Ave Monthly Water Use: Not metered

**Figure S20:** Sequential Lead Results - Sample Site #13 (Sept/Oct)

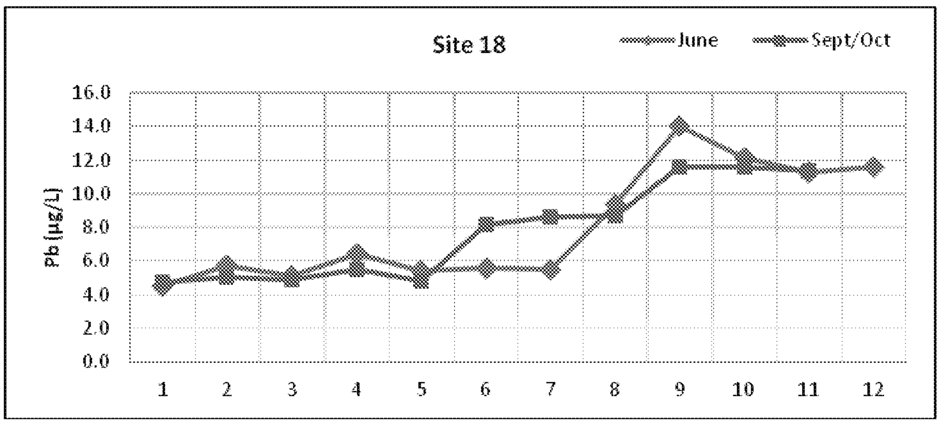
| Site 17 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.4 | 2.7 |
| 2 | 8.5 | 2.4 |
| 3 | 7.1 | 5.5 |
| 4 | 7.2 | 4.4 |
| 5 | 7.3 | 4.1 |
| 6 | 11 | 4.1 |
| 7 | 9.9 | 3.7 |
| 8 | 9.6 | 3.4 |
| 9 | **23** | 3.4 |
| 10 | **23** | 3.4 |
| 11 | **25** | 3.2 |
| 12 | 6.3 | 2.8 |
| 13 | | 2.6 |
| 14 | | 2.6 |




Disturbance(s): Meter replacement in 2008.
Approximate LSL Length: 58+ ft (17.7+ m)
Ave Monthly Water Use: 9,772 gal. (36,991 m)

**Figure S21:** Sequential Lead Results - Sample Site #17 (June and Sept/Oct)

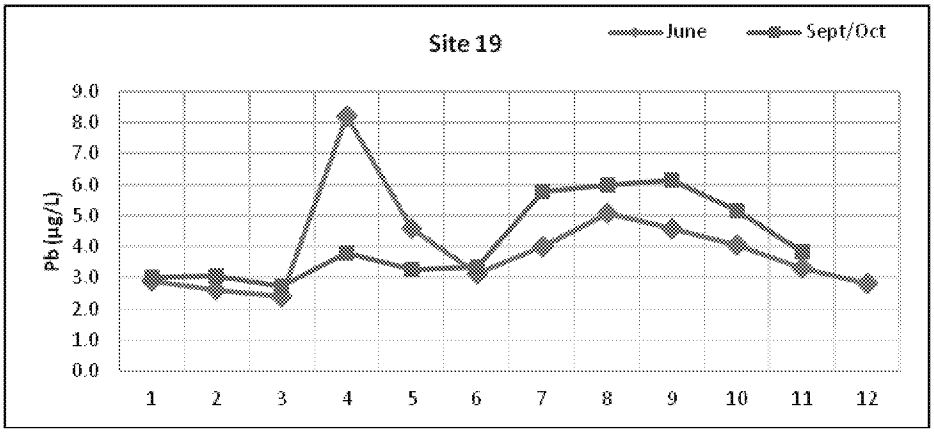
| Site 18 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 4.6 | 4.8 |
| 2 | 5.7 | 5.1 |
| 3 | 5.1 | 4.9 |
| 4 | 6.4 | 5.5 |
| 5 | 5.4 | 4.8 |
| 6 | 5.6 | 8.2 |
| 7 | 5.5 | 8.6 |
| 8 | 9.4 | 8.7 |
| 9 | 14 | 12 |
| 10 | 12 | 12 |
| 11 | 11 | 11 |
| 12 | 12 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 76 ft (23.2 m)
Ave Monthly Water Use: Not metered

**Figure S22:** Sequential Lead Results - Sample Site #18 (June and Sept/Oct)

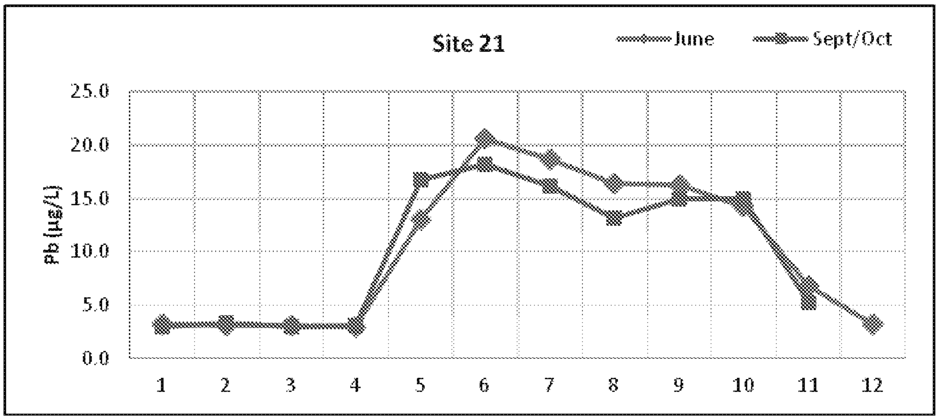
| Site 19 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.9 | 3.0 |
| 2 | 2.6 | 3.1 |
| 3 | 2.4 | 2.8 |
| 4 | 8.2 | 3.8 |
| 5 | 4.6 | 3.3 |
| 6 | 3.2 | 3.4 |
| 7 | 4.0 | 5.8 |
| 8 | 5.1 | 6.0 |
| 9 | 4.6 | 6.2 |
| 10 | 4.1 | 5.2 |
| 11 | 3.3 | 3.8 |
| 12 | 2.8 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 63 ft (19.2 m)
Ave Monthly Water Use: Not metered

**Figure S23:** Sequential Lead Results - Sample Site #19 (June and Sept/Oct)

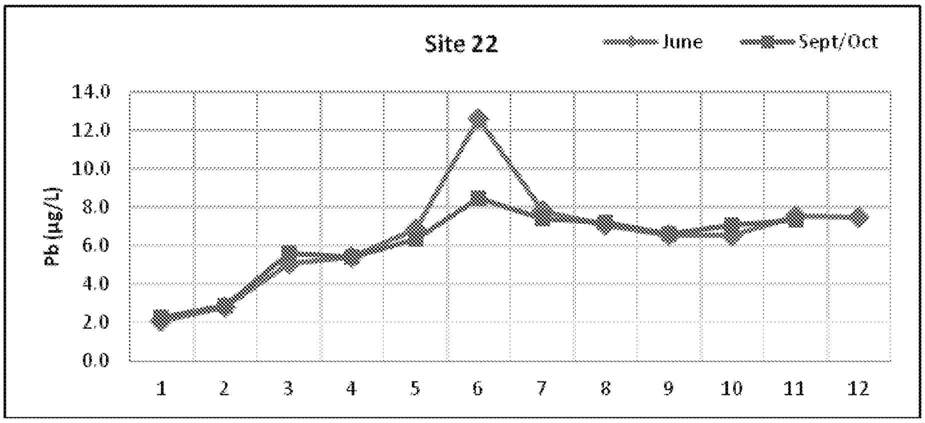
| Site 21 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 3.2 | 3.0 |
| 2 | 3.1 | 3.4 |
| 3 | 3.1 | 3.0 |
| 4 | 3.0 | 3.0 |
| 5 | 13 | **17** |
| 6 | **21** | **18** |
| 7 | **19** | **16** |
| 8 | **16** | 13 |
| 9 | **16** | 15 |
| 10 | 14 | 15 |
| 11 | 7.0 | 5.2 |
| 12 | 3.2 | |




Disturbance(s): Indeterminate
Approximate LSL Length: 46 ft (14.0 m)
Ave Monthly Water Use: Not metered

**Figure S24:** Sequential Lead Results - Sample Site #21 (June and Sept/Oct)

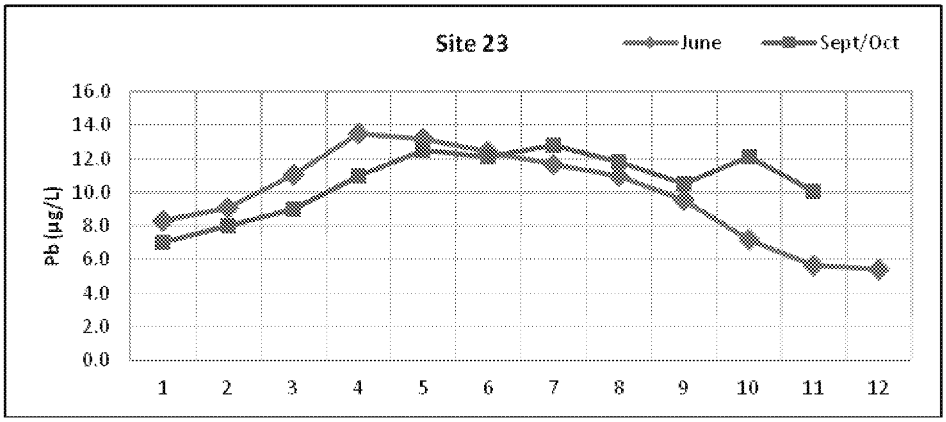
| Site 22 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.1 | 2.3 |
| 2 | 2.8 | 2.9 |
| 3 | 5.1 | 5.6 |
| 4 | 5.4 | 5.4 |
| 5 | 6.9 | 6.3 |
| 6 | 13 | 8.5 |
| 7 | 7.8 | 7.4 |
| 8 | 7.1 | 7.2 |
| 9 | 6.5 | 6.6 |
| 10 | 6.6 | 7.1 |
| 11 | 7.6 | 7.4 |
| 12 | 7.5 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 65 ft (19.8 m)
Ave Monthly Water Use: Not metered

**Figure S25:** Sequential Lead Results - Sample Site #22 (June and Sept/Oct)

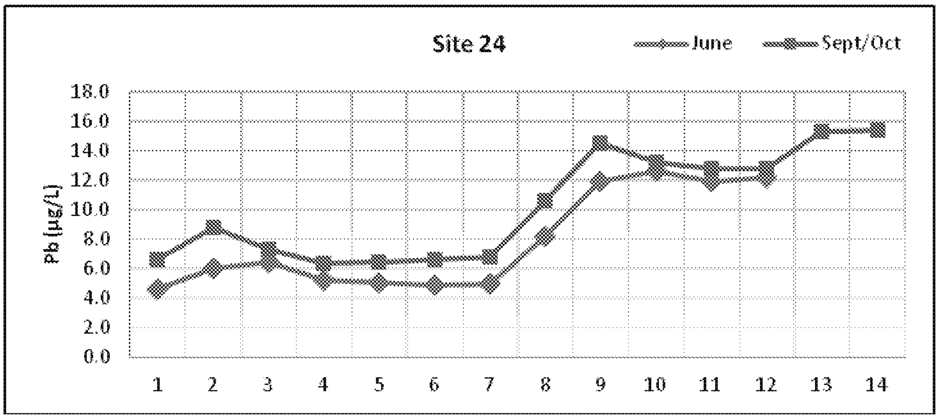
| Site 23 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 8.3 | 7.0 |
| 2 | 9.1 | 8.0 |
| 3 | 11 | 9.0 |
| 4 | 14 | 11 |
| 5 | 13 | 13 |
| 6 | 12 | 12 |
| 7 | 12 | 13 |
| 8 | 11 | 12 |
| 9 | 9.6 | 11 |
| 10 | 7.2 | 12 |
| 11 | 5.7 | 10 |
| 12 | 5.4 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 66 ft (20.1 m)
Ave Monthly Water Use: Not metered

**Figure S26:** Sequential Lead Results - Sample Site #23 (June and Sept/Oct)

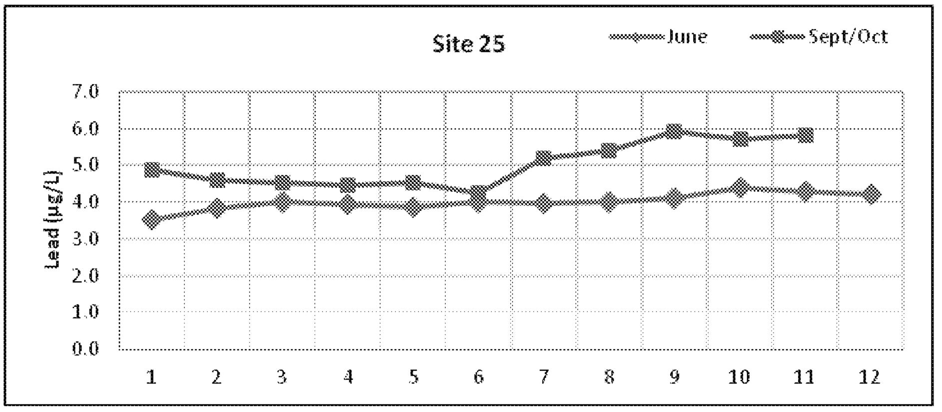
| Site 24 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 4.6 | 6.6 |
| 2 | 6.1 | 8.8 |
| 3 | 6.4 | 7.3 |
| 4 | 5.2 | 6.4 |
| 5 | 5.1 | 6.5 |
| 6 | 4.9 | 6.6 |
| 7 | 5.0 | 6.8 |
| 8 | 8.2 | 11 |
| 9 | 12 | 15 |
| 10 | 13 | 13 |
| 11 | 12 | 13 |
| 12 | 12 | 13 |
| 13 | | 15 |
| 14 | | 15 |




Disturbance(s): No known disturbance
Approximate LSL Length: 56 ft (17.1 m)
Ave Monthly Water Use: Not metered

**Figure S27:** Sequential Lead Results - Sample Site #24 (June and Sept/Oct)

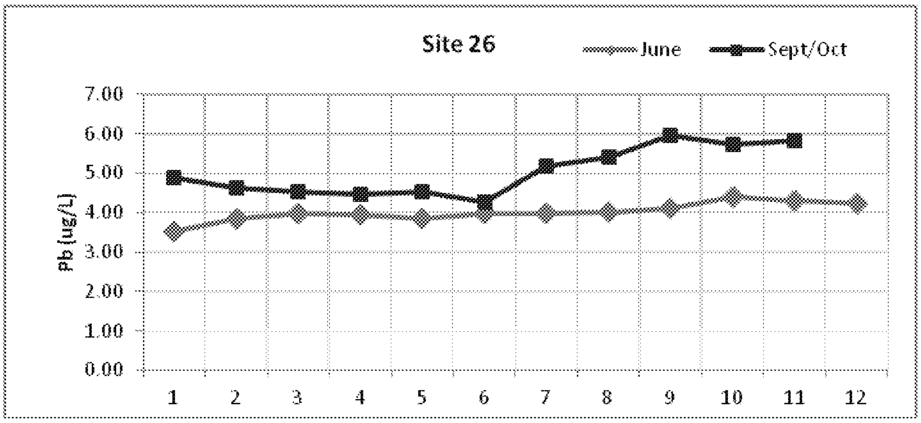
| Site 25 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 3.5 | 4.9 |
| 2 | 3.8 | 4.6 |
| 3 | 4.0 | 4.5 |
| 4 | 3.9 | 4.5 |
| 5 | 3.9 | 4.5 |
| 6 | 4.0 | 4.3 |
| 7 | 4.0 | 5.2 |
| 8 | 4.0 | 5.4 |
| 9 | 4.1 | 5.9 |
| 10 | 4.4 | 5.7 |
| 11 | 4.3 | 5.8 |
| 12 | 4.2 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 70 ft (21.3 m)
Ave Monthly Water Use: Not metered

**Figure S28:** Sequential Lead Results - Sample Site #25 (June and Sept/Oct)

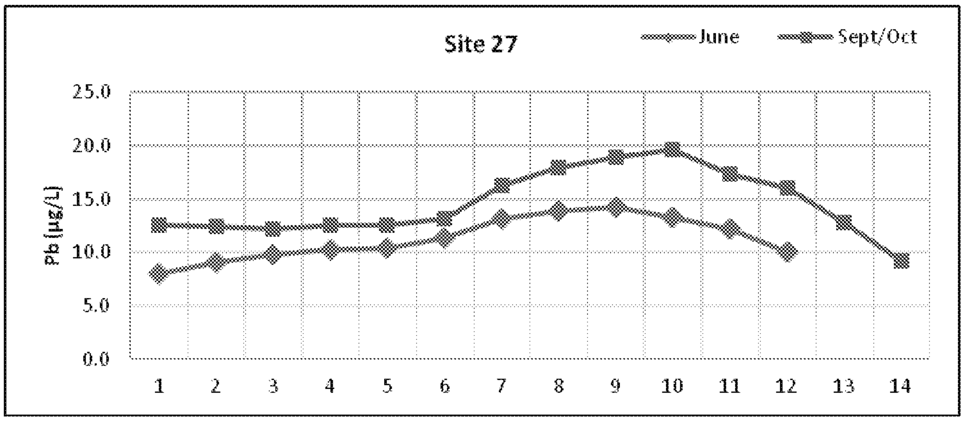
| Site 26 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 3.5 | 4.9 |
| 2 | 3.8 | 4.6 |
| 3 | 4.0 | 4.5 |
| 4 | 3.9 | 4.5 |
| 5 | 3.9 | 4.5 |
| 6 | 4.0 | 4.3 |
| 7 | 4.0 | 5.2 |
| 8 | 4.0 | 5.4 |
| 9 | 4.1 | 5.9 |
| 10 | 4.4 | 5.7 |
| 11 | 4.3 | 5.8 |
| 12 | 4.2 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 66 ft (20.1 m)
Ave Monthly Water Use: Not metered

**Figure S29:** Sequential Lead Results - Sample Site #26 (June and Sept/Oct)

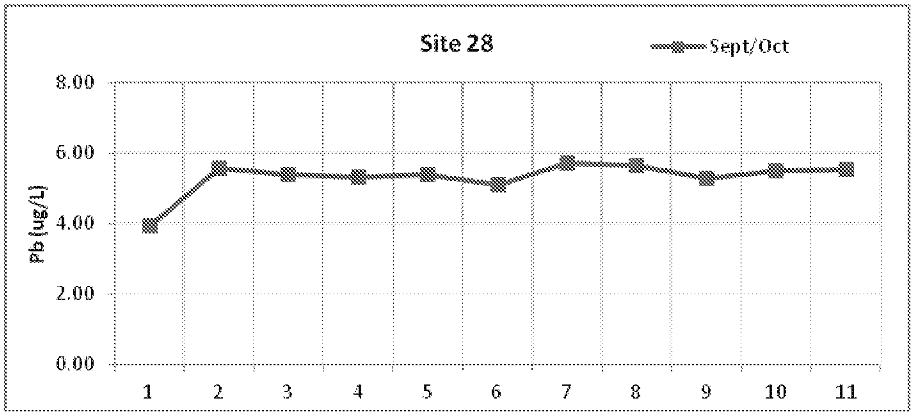
| Site 27 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 8.1 | 13 |
| 2 | 9.1 | 12 |
| 3 | 9.8 | 12 |
| 4 | 10 | 13 |
| 5 | 10 | 13 |
| 6 | 11 | 13 |
| 7 | 13 | **16** |
| 8 | 14 | **18** |
| 9 | 14 | **19** |
| 10 | 13 | **20** |
| 11 | 12 | **17** |
| 12 | 10 | **16** |
| 13 | | 13 |
| 14 | | 9.2 |




Disturbance(s): Meter replacement in 2010.
Approximate LSL Length: 47+ ft (14.3 m)
Ave Monthly Water Use: 4267 gal. (16,152 L)

**Figure S30:** Sequential Lead Results - Sample Site #27 (June and Sept/Oct)

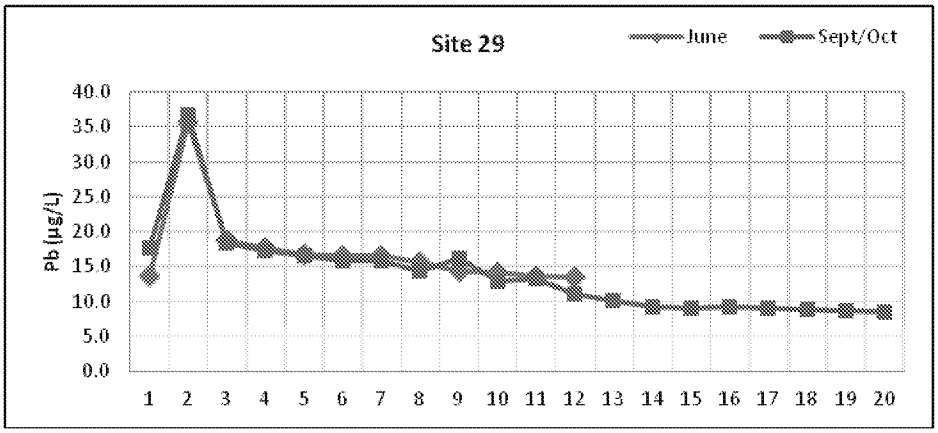
| Site 28 | |
|---|---|
| Liter | Sept/Oct |
| 1 | 3.9 |
| 2 | 5.6 |
| 3 | 5.4 |
| 4 | 5.3 |
| 5 | 5.4 |
| 6 | 5.1 |
| 7 | 5.7 |
| 8 | 5.7 |
| 9 | 5.3 |
| 10 | 5.5 |
| 11 | 5.6 |




Disturbance(s): Meter replacement in 2009.
Approximate LSL Length: 61+ ft (18.6+ m)
Ave Monthly Water Use: 4273 gal. (16,175 L)

**Figure S31:** Sequential Lead Results - Sample Site #28 (Sept/Oct)

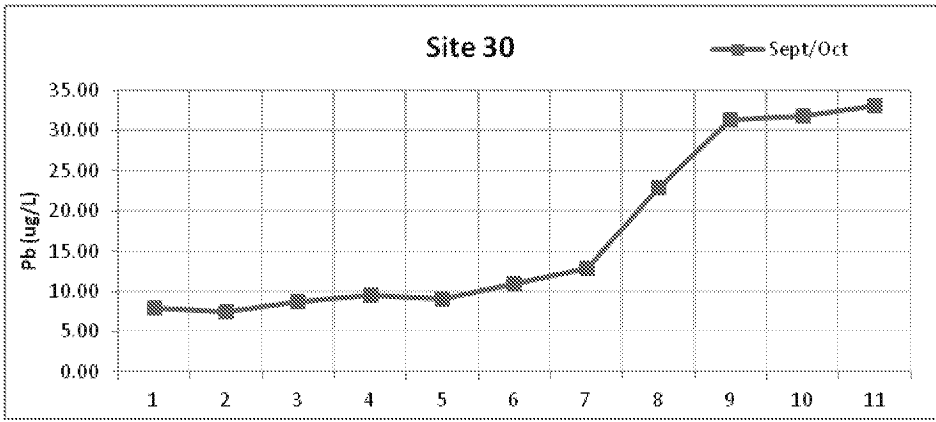
| Site 29 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 14 | **18** |
| 2 | **36** | **37** |
| 3 | **19** | **18** |
| 4 | **18** | **17** |
| 5 | **17** | **17** |
| 6 | **17** | **16** |
| 7 | **17** | **16** |
| 8 | **16** | 14 |
| 9 | 14 | **16** |
| 10 | 14 | 13 |
| 11 | 14 | 13 |
| 12 | 13 | 11 |
| 13 | | 10 |
| 14 | | 9.2 |
| 15 | | 9.0 |
| 16 | | 9.3 |
| 17 | | 9.0 |
| 18 | | 8.8 |
| 19 | | 8.7 |
| 20 | | 8.4 |




Disturbance(s): Probable Approximate LSL leak repair, meter installed in 2010.
Approximate LSL Length: 159 ft (48.5 m)
Ave Monthly Water Use: 1,438 gal. (5,443 L)

**Figure S32:** Sequential Lead Results - Sample Site #29 (June and Sept/Oct)

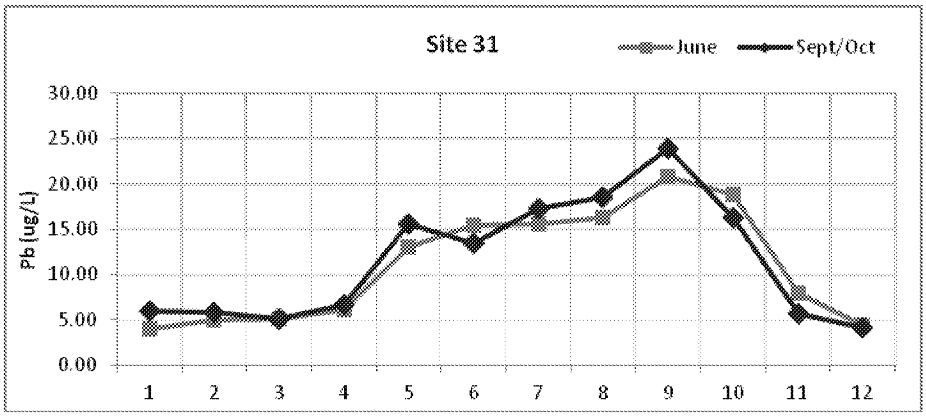
| Site 30 | |
|---|---|
| Liter | Sept/Oct |
| 1 | 7.9 |
| 2 | 7.5 |
| 3 | 8.7 |
| 4 | 9.5 |
| 5 | 9.1 |
| 6 | 11 |
| 7 | 13 |
| 8 | **23** |
| 9 | **31** |
| 10 | **32** |
| 11 | **33** |




Disturbance(s): Broken water main in 2000, sidewalk replaced & street re-surfacing.
Approximate LSL Length: 49+ ft (14.9 m)
Ave Monthly Water Use: Not metered

**Figure S33:** Sequential Lead Results - Sample Site #30 (Sept/Oct)

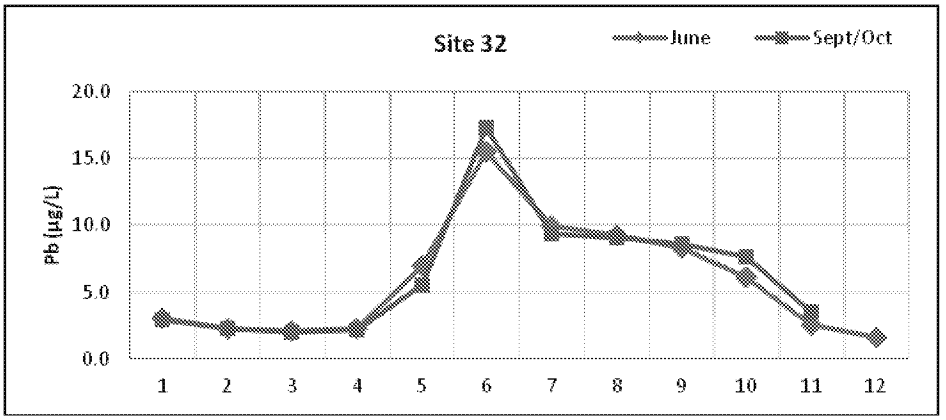
| Site 31 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 4.0 | 6.0 |
| 2 | 5.0 | 5.8 |
| 3 | 5.1 | 5.2 |
| 4 | 6.2 | 6.7 |
| 5 | 13 | **16** |
| 6 | 15 | 13 |
| 7 | **16** | **17** |
| 8 | **16** | **19** |
| 9 | **21** | **24** |
| 10 | **19** | **16** |
| 11 | 8 | 5.7 |
| 12 | 4.5 | 4.2 |




Disturbance(s): Approximate LSL leak repair in 2010.
Approximate LSL Length: 71+ ft (21.6+ m)
Ave Monthly Water Use: Not metered

**Figure S34:** Sequential Lead Results - Sample Site #31 (June and Sept/Oct)

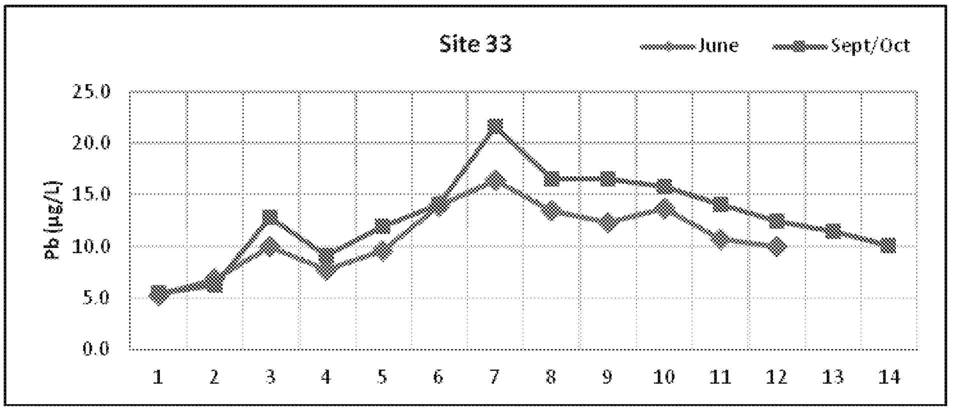
| Site 32 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 3.1 | 2.9 |
| 2 | 2.3 | 2.2 |
| 3 | 2.1 | 2.0 |
| 4 | 2.3 | 2.2 |
| 5 | 7.0 | 5.5 |
| 6 | **16** | **17** |
| 7 | 9.9 | 9.4 |
| 8 | 9.3 | 9.1 |
| 9 | 8.3 | 8.6 |
| 10 | 6.1 | 7.6 |
| 11 | 2.6 | 3.5 |
| 12 | 1.7 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 43 ft (13.1 m)
Ave Monthly Water Use: Not metered

**Figure S35:** Sequential Lead Results - Sample Site #32 (June and Sept/Oct)

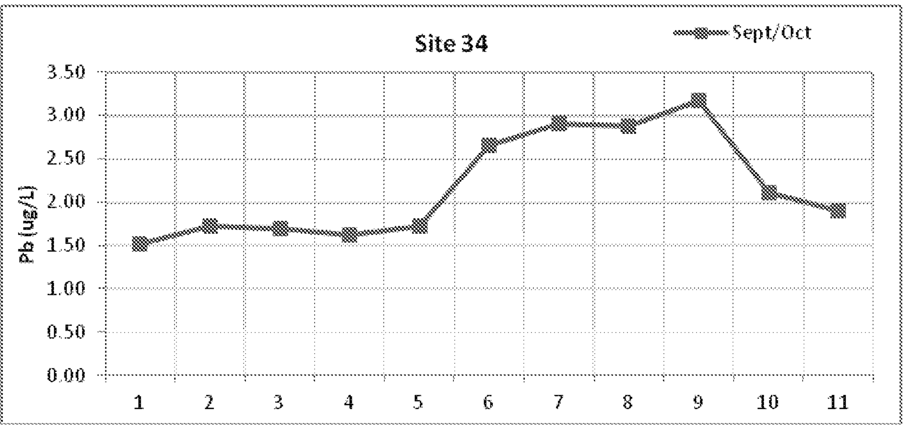
| Site 33 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 5.2 | 5.5 |
| 2 | 6.9 | 6.3 |
| 3 | 10 | 13 |
| 4 | 7.7 | 9.1 |
| 5 | 9.6 | 12 |
| 6 | 14 | 14 |
| 7 | **16** | **22** |
| 8 | 14 | **17** |
| 9 | 12 | **17** |
| 10 | 14 | **16** |
| 11 | 11 | 14 |
| 12 | 10 | 12 |
| 11 | | 12 |
| 12 | | 10 |




Disturbance(s): Indeterminate
Approximate LSL Length: 43+ ft (13.1 m)
Ave Monthly Water Use: Not metered

**Figure S36:** Sequential Lead Results - Sample Site #33 (June and Sept/Oct)

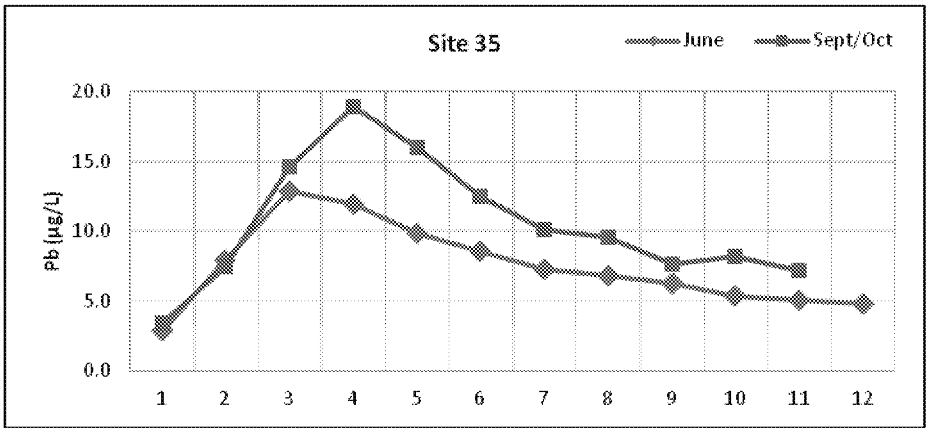
| Site 34 | |
|---|---|
| Liter | Sept/Oct |
| 1 | 1.5 |
| 2 | 1.7 |
| 3 | 1.7 |
| 4 | 1.6 |
| 5 | 1.7 |
| 6 | 2.7 |
| 7 | 2.9 |
| 8 | 2.9 |
| 9 | 3.2 |
| 10 | 2.1 |
| 11 | 1.9 |




Disturbance(s): No known disturbance
Approximate LSL Length: Unknown
Ave Monthly Water Use: Not metered

**Figure S37:** Sequential Lead Results - Sample Site #34 (Sept/Oct)

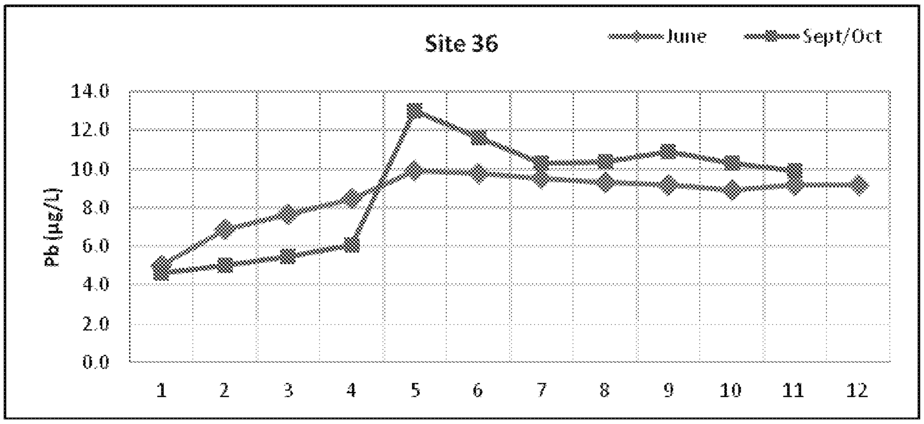
| Site 35 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 2.9 | 3.4 |
| 2 | 7.9 | 7.4 |
| 3 | 13 | 15 |
| 4 | 12 | **19** |
| 5 | 9.9 | **16** |
| 6 | 8.6 | 13 |
| 7 | 7.3 | 10 |
| 8 | 6.8 | 9.6 |
| 9 | 6.2 | 7.6 |
| 10 | 5.3 | 8.2 |
| 11 | 5.0 | 7.2 |
| 12 | 4.8 | |




Disturbance(s): Meter installed in Aug 2011 (between June and Sept/Oct sampling).
Approximate LSL Length: 80 ft (24.4 m)
Ave Monthly Water Use: 4,667 gal. (17,667 L) – Data available only for Aug-Oct 2011

**Figure S38:** Sequential Lead Results - Sample Site #35 (June and Sept/Oct)

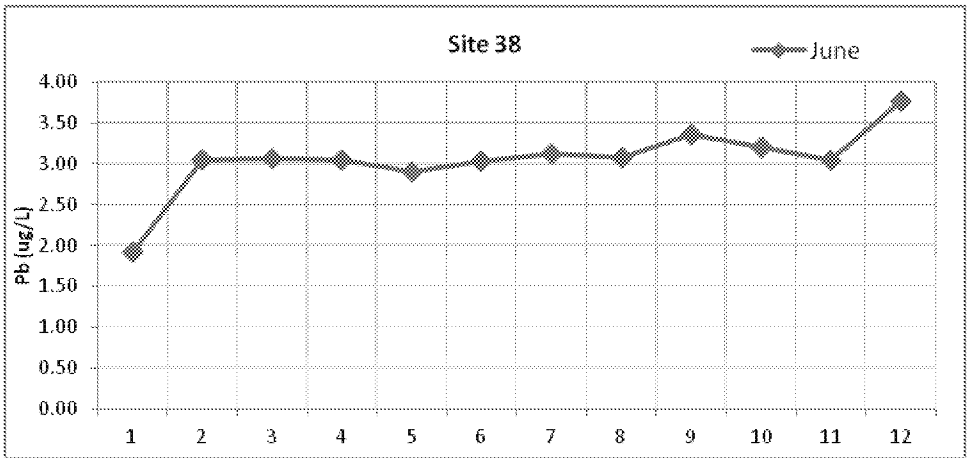
| Site 36 | | |
|---|---|---|
| Liter | June | Sept/Oct |
| 1 | 5.0 | 4.6 |
| 2 | 6.9 | 5.0 |
| 3 | 7.7 | 5.5 |
| 4 | 8.5 | 6.1 |
| 5 | 9.9 | 13 |
| 6 | 9.8 | 12 |
| 7 | 9.5 | 10 |
| 8 | 9.3 | 10 |
| 9 | 9.2 | 11 |
| 10 | 8.9 | 10 |
| 11 | 9.2 | 9.9 |
| 12 | 9.2 | |




Disturbance(s): No known disturbance
Approximate LSL Length: 83+ ft (25.3 m)
Ave Monthly Water Use: Not metered

**Figure S39:** Sequential Lead Results - Sample Site #36 (June and Sept/Oct)

| Site 38 | |
|---|---|
| Liter | June |
| 1 | 1.9 |
| 2 | 3.0 |
| 3 | 3.1 |
| 4 | 3.0 |
| 5 | 2.9 |
| 6 | 3.0 |
| 7 | 3.1 |
| 8 | 3.1 |
| 9 | 3.4 |
| 10 | 3.2 |
| 11 | 3.0 |
| 12 | 3.8 |




Disturbance(s): No known disturbance
Approximate LSL Length: 51 ft (15.5 m)
Ave Monthly Water Use: Not metered

**Figure S40:** Sequential Lead Results - Sample Site #38 (June)

## Sampling collection and reporting instructions and forms

***March/April sampling*** – The sampling instructions and forms below were used in the March/April sampling. Sampling was scheduled to conclude in March, but the sampling ran into April. As a result of the instructions below, some volunteers sampled one day at the kitchen tap and one day at the bathroom tap. The intent was to have all samples collected from the same tap, so volunteers that split the samples were asked to collect replacement samples so that a complete set of four samples was collected at the same tap. We chose the kitchen tap, and all samples collected thereafter were also collected at the kitchen tap. In addition, the 45-second flushed sampling protocol was not used after the March/April sampling due to the complication with corroded galvanized pipe.

## General Sampling Instructions

You will be taking a total of 8 samples for this study. One set of 4 samples will be taken in March 2011 and one set of 4 samples (using the same instructions) will be taken in August 2011.

General Instructions for all four samples of a set
*Sample #1 and Sample #2 must be collected one after another on the same day.*
*Sample #3 and Sample #4 must also be collected one after another on the same day, and within the same week as Sample #1 and Sample #2.*

All samples should be collected from taps that are generally used by your household for drinking water. Do not collect samples from a taps that have not been used within the last 24 hours. Use a kitchen or bathroom cold-water faucet for your sampling.

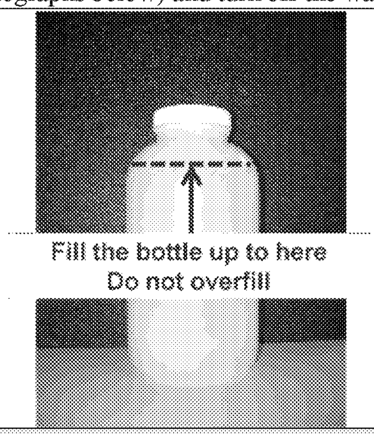
Do not collect samples from a tap that has a water filter or is connected to a water softener. If you have a water softener or water filter on your kitchen tap, collect your sample from a bathroom tap that is not attached to the water softener or water filter, if possible.

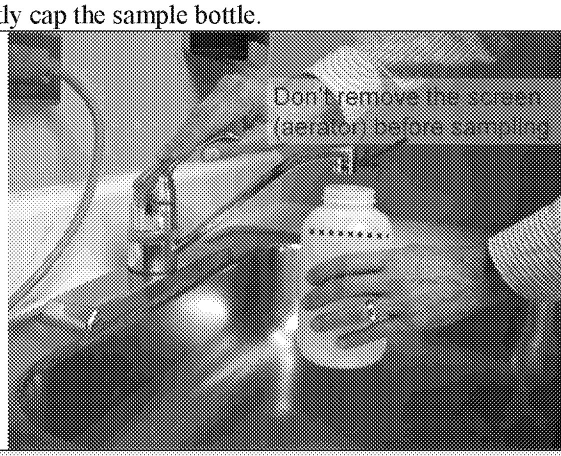
## Instructions for Collecting Sample #1

***Important: Please make sure you use the bottle labeled 'Sample #1' for your first sample!***

Collecting Sample #1: The first sample is to be collected after water throughout the household *has not been used for a minimum of 6 hours* (example: midnight to 6am). During these 6 hours, do not flush toilets, shower, or run water from other faucets. The best time to collect samples is either:
1) First thing in the morning, before any water is used in the household; or 2) Immediately upon returning from work, and prior to using any water, as long as water has not been used in the household during the day.

1. When you are ready to collect your first sample, use the sample bottle labeled 'Sample #1'.
2. Do not run any water from the tap before collecting the first sample.
3. Place the opened sample bottle below the faucet and gently open the cold water tap.
4. Fill the sample bottle as you would normally fill a glass of water for drinking, up to the neck of the bottle (see photographs below) and turn off the water. Tightly cap the sample bottle.




## Instructions for Collecting Sample #2

*Important: Please make sure you use the bottle labeled 'Sample #2' for your second sample!*

Collecting Sample #2: This sample is to be collected from the same faucet as Sample #1, immediately after collecting Sample #1.

1. Immediately after collecting Sample #1, run the water for 45 seconds. Shut off the water, and place the opened

sample bottle (labeled Sample #2) below the faucet and gently open the cold water tap.
2. Fill the sample bottle as you would normally fill a glass of water for drinking, up to the neck of the bottle (see photographs on first page) and turn off the water. Tightly cap the sample bottle.

## Instructions for Collecting Sample #3

***Important: Please make sure you use the bottle labeled 'Sample #3' for your third sample!***

Collecting Sample #3: Collect on a different day in the same week as Samples #1 & #2.

1. *Before* letting the water sit for a minimum of 6 hours, run the water from the faucet for 5 minutes at a high rate, and then do not use any water in the household for at least 6 hours after that (Example: Run the water for 5 minutes at midnight before going to bed, and then do not use any water in the household until collecting the third sample at 6 am the following morning).
2. Do not run any more water from the tap before collecting the third sample. Place the opened sample bottle below the faucet and gently open the cold water tap.
3. Fill the sample bottle as you would normally fill a glass of water for drinking, up to the neck of the bottle (see photographs on first page) and turn off the water. Tightly cap the sample bottle.

## Instructions for Collecting Sample #4

***Important: Please make sure you use the bottle labeled 'Sample #4' for your fourth sample!***

Collecting Sample #4: This sample is to be collected from the same faucet as Sample #3.

1. Immediately after collecting Sample #3, run the water for 45 seconds. Shut off the water, and place the opened sample bottle (labeled Sample #4) below the faucet and gently open the cold water tap.
2. Fill the sample bottle as you would normally fill a glass of water for drinking, up to the neck of the bottle (see photographs on first page) and turn off the water. Tightly cap the sample bottle.

**Figure S41:** March/April sampling instructions.

## Sample Collection and Reporting Page

**Sample Reporting – Sample #1** | **EPA Use: Visible Particulate? Yes ☐ No ☐**

**Sample ID (from Sample Bottle #1): ______________ Date/time Sample #1 was collected: ____________________**

**Volunteer ID: ___________________ Sampling Location: Kitchen Faucet ☐ Bathroom Faucet ☐**

**Date/time the water was last used in household before collecting Sample #1: ___________________________________**

**Was sample #1 collected from a faucet that has a water softener or water filter? Yes ☐ No ☐**

**Sample Reporting – Sample #2** | **EPA Use: Visible Particulate? Yes ☐ No ☐**

**Sample ID (from Sample Bottle #2): _____________ Date/time Sample #2 was collected: ____________________**

**Volunteer ID: ____________________ Sampling Location: Kitchen Faucet ☐ Bathroom Faucet ☐**

**Date/time the water was last used in household before collecting Sample #2: ___________________________________**

**Was Sample #2 collected from the same faucet as Sample #1: Yes ☐ No ☐**

**Sample Reporting – Sample #3** | **EPA Use: Visible Particulate? Yes ☐ No ☐**

**Sample ID (from Sample Bottle #3): ______________ Date/time Sample #3 was collected: ____________________**

**Volunteer ID: ___________________ Sampling Location: Kitchen Faucet ☐ Bathroom Faucet ☐**

**Date/time the faucet was flushed before collecting Sample #3: ___________________________________**

**Was sample #3 collected from a faucet that has a water softener or water filter? Yes ☐ No ☐**

**Sample Reporting – Sample #4** | **EPA Use: Visible Particulate? Yes ☐ No ☐**

**Sample ID (from Sample Bottle #4): _____________ Date/time Sample #4 was collected: ____________________**

**Volunteer ID: ____________________ Sampling Location: Kitchen Faucet ☐ Bathroom Faucet ☐**

**Date/time the faucet was flushed before collecting Sample #4: ___________________________________**

**Was Sample #4 collected from the same faucet as Sample #3: Yes ☐ No ☐**

**Have there been any plumbing repairs or plumbing work done within the household during the last six months (including installation of new faucets)? Yes ☐ No ☐**

**If yes, explain briefly (*Example – 'New faucet installed one week ago'*):**

**FOR EPA USE: Samples received by _______________________ Date/Time: ______________________**

**Samples transferred to Region 5 Laboratory by _______________________ Date/Time: ___________________**

***Volunteer Certification: I have read the sampling instructions and have collected the samples in accordance with the instructions provided.***

_______________________________________ ***OR*** _______________________________

***Signature/Date*** ***Volunteer ID/Date***

**Figure S42:** March/April sample collection and reporting form.

*Sequential Sampling Instructions for June* – The sampling instructions and forms below were used in the June sequential sampling.

## Sequential Sampling Instructions

**Please read all instructions before beginning your sampling**

**General Information**

•Use only the kitchen faucet for all of these samples.

•Use only **cold water** and open the cold water tap all the way when filling the bottles.

•Fill each bottle to the top of the label on the sample bottle.

**Sampling Instructions**

•The night before sampling (right before everyone goes to bed) run the water from the kitchen tap for at least 5 minutes. Write down the date/time you finished running the water on the form on the back side of this page.

•The water must sit motionless in the home plumbing for at least 6 hours before collecting the samples so do not use water in the home after you finished running the water and until all samples are collected the following morning. Showering, flushing toilets, or other water use will affect the sampling results. It may help to tape a sign in the kitchen and bathrooms with a reminder not to use the water, in case people forget.

• The bottles are numbered, and it is very important to collect them in order (Sample 1 first, Sample 2 second, etc.).

•In the morning, when you are ready to sample, place the open bottles in order by sample number. You will be collecting the samples without shutting off the water in between samples, so you should remove the caps from all bottles so that you have all of the bottles ready to fill. You can put the caps on after all samples have been collected. Try not to let any water spill in between samples.

•Write down the date/time right before you sample on the form on the back side of this page.

•Begin by placing the Sample 1 bottle under the faucet and open the **cold water** slowly until the faucet is fully open. While one bottle is filling, grab the next bottle so that you are ready to move it under the faucet quickly.

•Once the bottle is filled to the top of the label, quickly place the Sample 2 bottle under the faucet, and continue until you have filled all sample bottles.

## Sequential Sampling – Sample Collection and Reporting Form

**Volunteer ID:** ________________

**Sampling Information**

**Date/time the water was last used in household (the night before collecting the samples):** ______________________________

**Date/Time Volunteer Began Collecting Samples:** ________________________

**Were All Samples Collected from the Kitchen Tap? Yes ☐ No ☐**

**FOR EPA USE: Samples received by** __________________________ **Date/Time:** ________________

**Samples transferred to Region 5 Laboratory by** ____________________ **Date/Time:** ________________

**EPA Use: Visible Particulate in any samples? Yes ☐ No ☐** **If Yes – List Samples With Particulate** ______________________________

***Volunteer Certification: I have read the sampling instructions and have collected the samples in accordance with the instructions provided.***

______________________________________ ***OR*** ______________________________

***Signature/Date*** ***Volunteer ID/Date***

**Figure S43**: June sampling instructions and sample collection and reporting form.

***Sampling instructions for September/October*** – In the final round of sampling, the number and type of samples was customized to each site and sites collected 3 days of sampling. The instructions below were for a site collecting one NHU First-draw sample, 11 sequential samples and a 2 flushed samples. Some sites collected additional sequential samples and some collected 3 flushed samples instead of two.

<table>
<tr><th>Sampling Instructions</th></tr>
<tr><th>Please read all instructions before you start sampling.</th></tr>
<tr><td>General Information<br>✓ Use only the kitchen faucet for all of these samples.<br>✓ Use only cold water.<br>✓ Open the cold water tap all the way when filling the bottles.<br>✓ Fill each bottle to the top of the label on the sample bottle.</td></tr>
<tr><td>Sampling Instructions<br>✓ There are three different sets of samples for you to collect (Sample Set #1, #2 and #3).<br>✓ Each set will be taken on a different day. (The three sampling sets do not have to be taken on three days in a row.)<br>✓ A section of the reporting form (attached) needs to be filled in for each day of sampling.</td></tr>
<tr><td>A) Sample Set #1 (1 bottle, Blue Label)<br>1. The water must sit motionless in the home plumbing for at least 6 hours before collecting the sample. Typically, the night before taking the sample, make sure that no one uses water in the home until you collect the sample from the kitchen the following morning.<br><br>2. In the morning, when you are ready to sample, write down the date/time on the attached form.<br><br>3. Fill up the bottle with the BLUE LABEL. That's it for collecting the first sample set.</td></tr>
<tr><td>B) Sample Set #2 "Sequential Sampling" (11 bottles, WHITE LABELS)<br>1. The night before sampling (right before everyone goes to bed) run the water from the kitchen tap for at least 5 minutes. Write down the date/time you finished running the water on the form. After running the water for 5 minutes, it should sit motionless in the home plumbing for at least 6 hours.<br><br>2. In the morning, your first water usage should be collecting eleven samples in a row (one after another). Use the bottles with the WHITE LABELS. The samples should be collected without shutting off the water in between samples. To do this, remove the caps from all eleven bottles before you turn on the water.<br><br>3. Place the eleven open bottles in order by sample number before you start collecting the samples Try not to waste water in between the samples. You can put the caps on after all 11 samples have been collected. The bottles are numbered Seq 01, to Seq 11. It is very important to collect the samples in order (Seq 01 first, Seq 02 second, etc.).<br><br>4. Use the attached reporting form to note the date and time that you started taking the sample set.</td></tr>
<tr><td>C) Sample Set #3 (2 Bottles, GREEN LABEL and YELLOW LABEL)<br>1. The night before sampling (right before everyone goes to bed) run the water from the kitchen tap for at least 5 minutes. Write down the date/time you finished running the water on the form. After running the water for 5 minutes, it should sit motionless in the home plumbing for at least 6 hours.<br><br>2. In the morning, when you are ready to sample, write down the date/time on the attached reporting form.<br><br>3. Run the water for 3 minutes, then collect a sample in the jar with the GREEN LABEL. Continue to let the water run for an additional 2 minutes (for a total of 5 minutes), and collect the final sample in the bottle with the YELLOW LABEL.</td></tr>
</table>

**Figure S44:** Sept/Oct sampling instructions.

| Sample Collection and Reporting – Sampling set # 1 (Blue label) |
|---|
| Volunteer ID: ________________ |
| Sampling Information |
| Date/time the water was last used in household (the night before collecting the samples): ______________________________<br>Date/Time Volunteer Began Collecting Samples: __________________________<br>Were All Samples Collected from the Kitchen Tap? Yes ☐ No ☐ |
| FOR EPA USE: Samples received by __________________________ Date/Time: ________________<br>Samples transferred to Region 5 Laboratory by ____________________ Date/Time: ________________<br>EPA Use: Visible Particulate in any samples? Yes ☐ No ☐ If Yes – List Samples With Particulate ________________ |
| **Sample Collection and Reporting - Sampling set # 2 (11 samples, White labels)** |
| Volunteer ID: ________________ |
| Sampling Information |
| Date/time the water was last used in household (the night before collecting the samples): ______________________________<br>Date/Time Volunteer Began Collecting Samples: __________________________<br>Were All Samples Collected from the Kitchen Tap? Yes ☐ No ☐ |
| FOR EPA USE: Samples received by __________________________ Date/Time: ________________<br>Samples transferred to Region 5 Laboratory by ____________________ Date/Time: ________________<br>EPA Use: Visible Particulate in any samples? Yes ☐ No ☐ If Yes – List Samples With Particulate ________________ |
| **Sample Collection and Reporting - Sampling set # 3 (Green and Yellow labels)** |
| Volunteer ID: ________________ |
| Sampling Information |
| Date/time the water was last used in household (the night before collecting the samples): ______________________________<br>Date/Time Volunteer Began Collecting Samples: __________________________<br>Were All Samples Collected from the Kitchen Tap? Yes ☐ No ☐ |
| FOR EPA USE: Samples received by __________________________ Date/Time: ________________<br>Samples transferred to Region 5 Laboratory by ____________________ Date/Time: ________________<br>EPA Use: Visible Particulate in any samples? Yes ☐ No ☐ If Yes – List Samples With Particulate ________________ |

***Volunteer Certification: I have read the sampling instructions and have collected the samples in accordance with the instructions provided.***

________________________________________ ***OR*** ______________________________

***Signature/Date*** ***Volunteer ID/Date***

**Figure S45:** Sept/Oct sample collection and reporting form.

## Literature Cited/References

1. Triantafyllidou, S.; Edwards, M., Galvanic corrosion after simulated small-scale partial lead service line replacements. *Journal American Water Works Association* **2011,** *103*, (9), 85-+.
2. Renner, R., Reaction to the Solution: Lead Exposure Following Partial Service Line Replacement. *Environmental health perspectives* **2010,** *118*, (5).
3. Cartier, C.; Arnold Jr, R. B.; Triantafyllidou, S.; Prévost, M.; Edwards, M., Effect of Flow Rate and Lead/Copper Pipe Sequence on Lead Release from Service Lines. *Water Research* **2012,** *46*, (13), 4142-4152.

# How Do I Know if I Have a Lead Service Line?

There are three main ways a homeowner can determine whether any portion of the service line is made of lead.

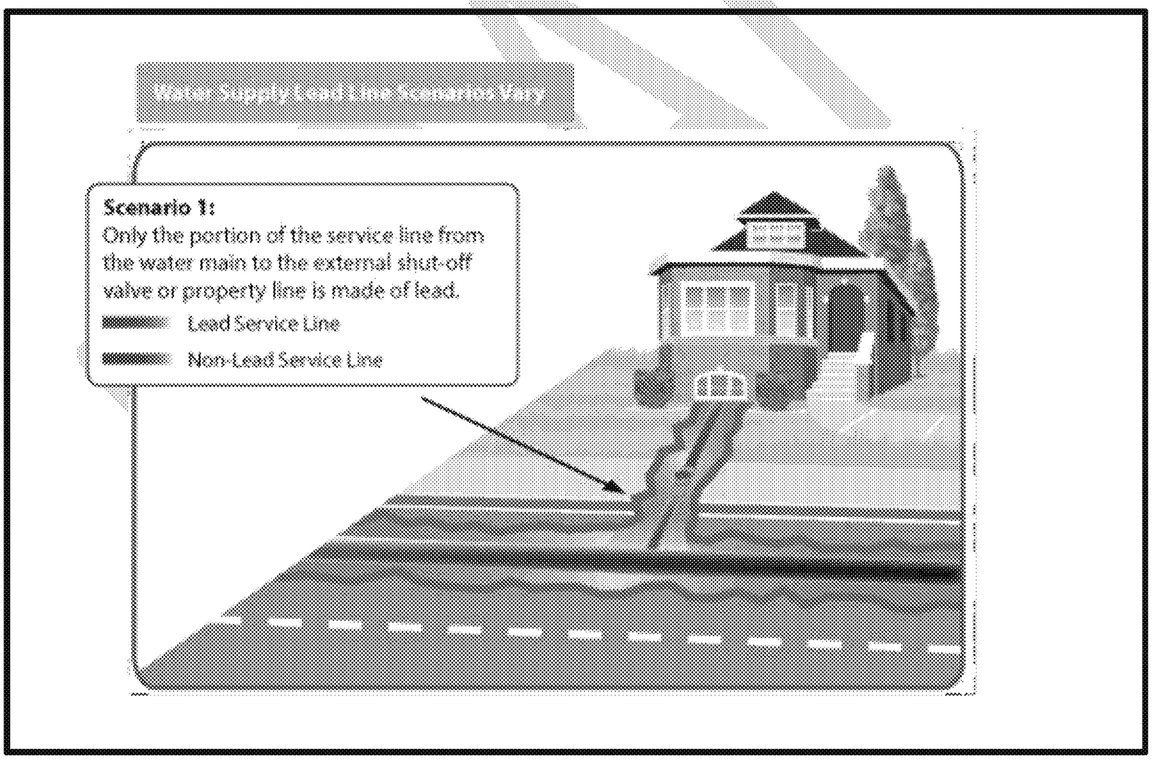
- You can inspect your own pipes;
- Call your water provider; or
- Call a licensed plumber.

***Inspecting your own pipes.***

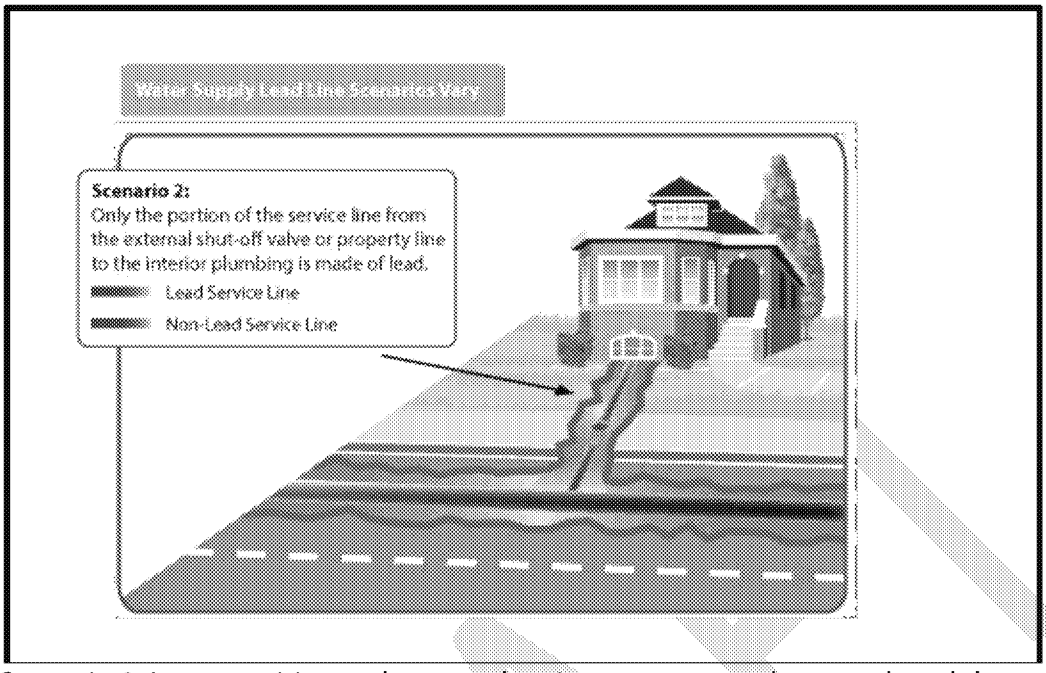
If the plumbing in your home is accessible, you may be able to inspect your own plumbing.

In order to inspect your pipes to see if any portion of the service line is made of lead, you should know that the entire service line or only a portion of the service line can be made of lead pipe. This varies widely in different cities and towns and even among homes in the same city or town.

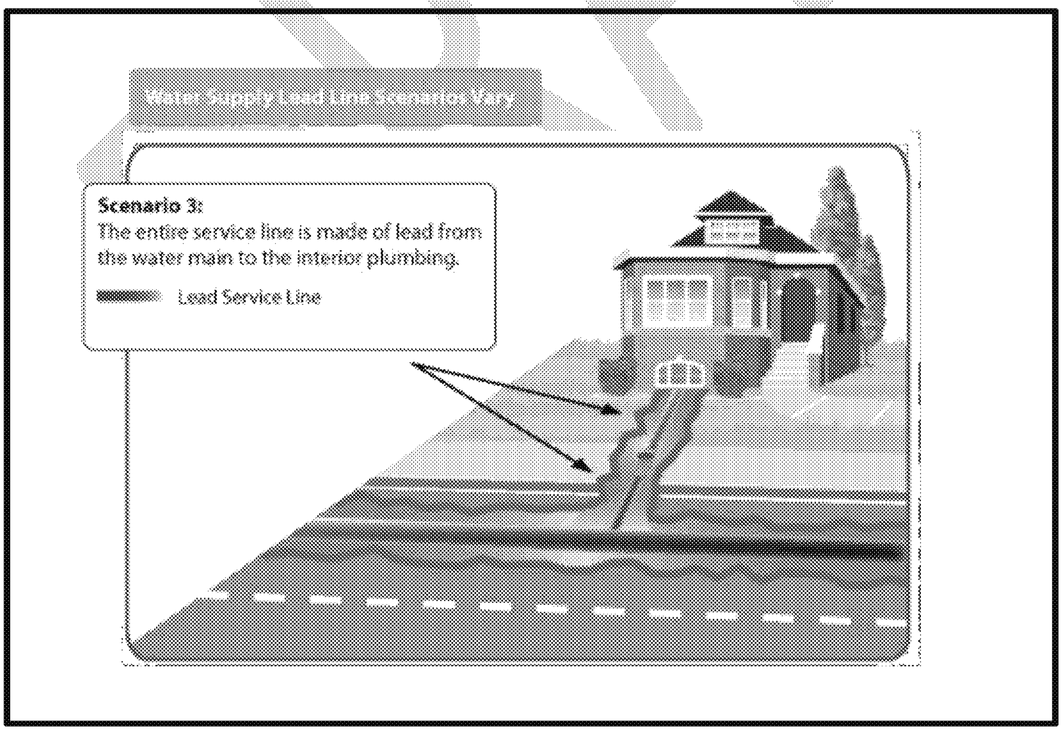
There are four common scenarios:




Scenario 1: Only the portion of the service line from the water main to the external shut-off valve or property line is made of lead, and the portion from the external shut-off valve or property line to the home is made of a different material, such as copper or galvanized iron pipe.




Scenario 2: In some cities and towns, the city or town may have replaced the portion of the lead service line from the water main to the property line or external shut-off valve to the property with another pipe material, and only the portion of the service line from the property line or external shut-off valve to the home is now lead.



Scenario 3: In some cities and towns, the entire service line from the water main to the home may be made of lead.

Scenario 4: A short segment of lead pipe commonly called a 'lead gooseneck' (see figure 6) connects the water main to the service line. You cannot inspect the gooseneck since it is under the street.

***What do lead service lines look like?***

Lead service lines are generally a dull gray color and are very soft. You can identify them easily by carefully scratching the surface of the pipe with a key. If the pipe is made of lead, the area you've scratched will turn a bright silver color as shown in figures 1 and 2 below. Do not use a knife or other sharp instrument and take care not to puncture a hole in the pipe.

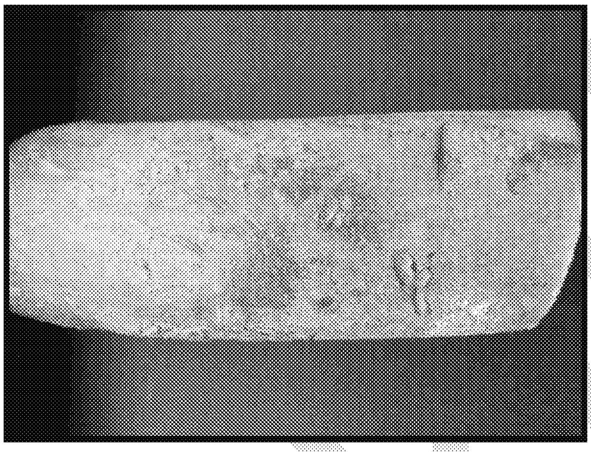


Figure 1: Lead service line before scratching.

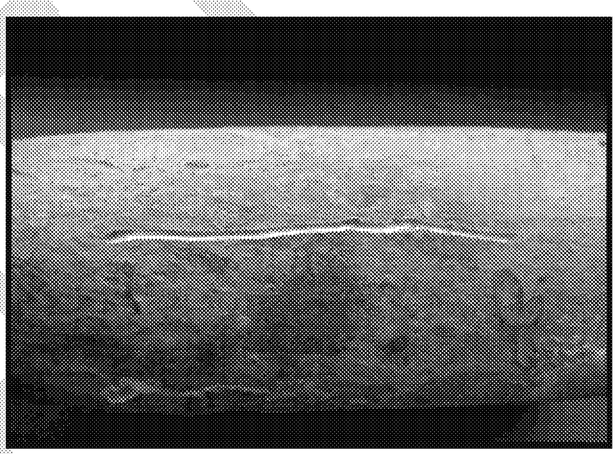


Figure 2: Lead service line after scratching.

Lead service lines can be connected to the residential plumbing using solder and have a characteristic solder 'bulb' at the end, a compression fitting, or other connector made of galvanized iron or brass/bronze (see figures 3 and 4).

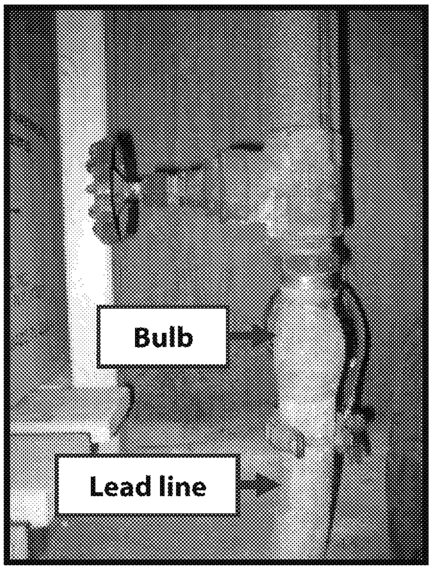



Figure 3: Lead service line comes up through the basement floor and is connected to household plumbing with a solder 'bulb'.

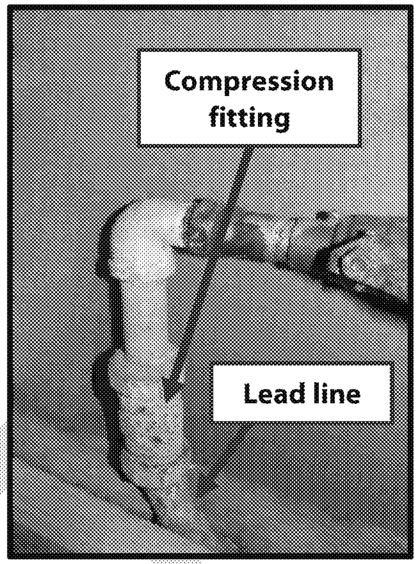



Figure 4: Lead service line comes up through basement floor and is connected to the household plumbing using a compression fitting.

The lead service line often ends just inside the front or side wall of the home, but may extend further into the building as shown in figure 5 below, where the lead service line comes out of the basement floor to the water meter and then back into the floor, continuing further into the building beneath the basement floor.

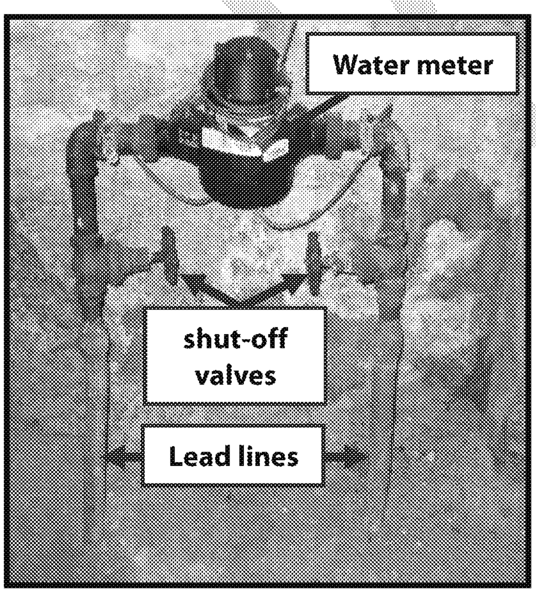



Figure 5: Lead service line comes up through the basement floor, through the meter, and back under the floor.

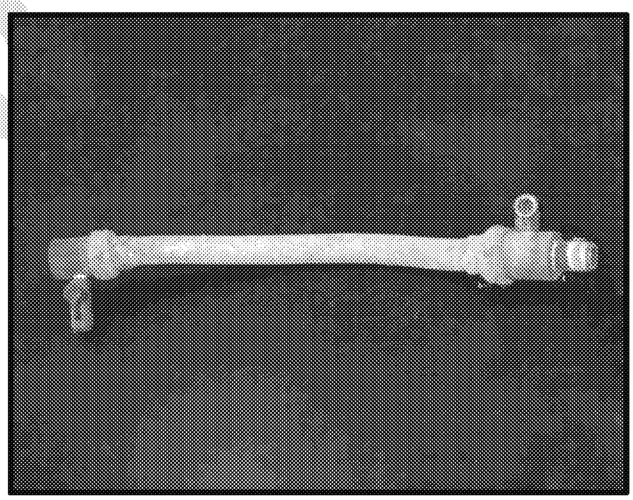


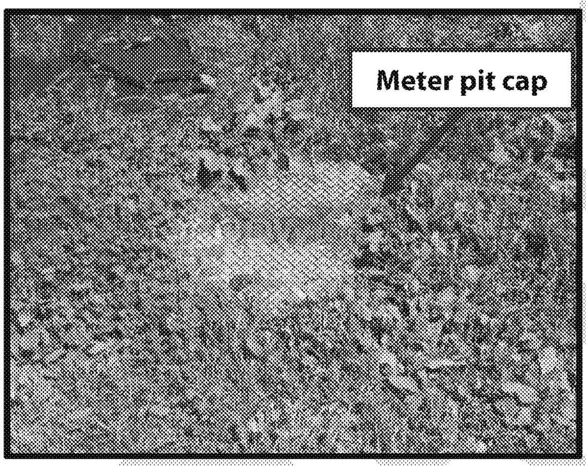
Figure 6: A lead gooseneck is a short lead pipe that connects from the water main to the service line.

Where only the public water system portion of the service line is made of lead, or where the plumbing is not visible in your home, you may not be able to see the lead pipe from inside your home.

States and local governments stopped using lead pipes at different times. If your meter was installed before lead pipes were banned in your location and you have a meter pit, open the meter pit (see figures 7 and 8) and check the pipe on either side of the meter, to see if it is made of lead.

If your meter was installed after lead pipes were banned in your location, you may not be able to see any lead pipe in the meter pit or meter vault, since a different material would have been used to connect the meter.





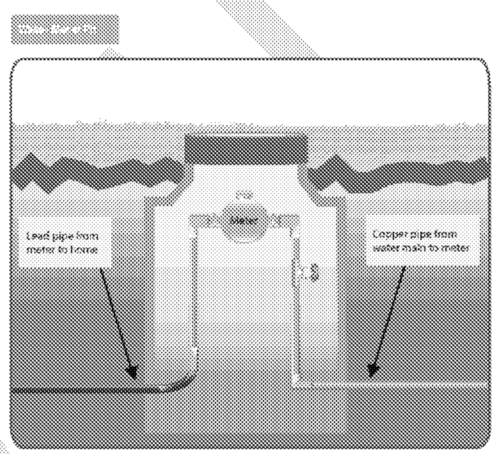




Figure 7: If your home has a water meter, your water meter may be in your home or in a 'meter pit' or 'meter vault' as shown above.

Figure 8: If your meter was installed before lead pipes were banned in your location, open the meter pit or meter vault and check pipes on both sides of the meter.

***Contact your water provider.*** If you cannot visually inspect your plumbing or your meter was installed after lead pipes were banned in your location, you can call your water provider.

In some cases, your water provider may be able to tell you if you have a lead service line. The telephone number to your water provider is usually on your water bill. Ask if your home has any portion of the service line made of lead.

***Call a licensed plumber.*** If your water provider does not know if any portion of your service line is made of lead, have a licensed plumber inspect your service line to see whether any portion of it is made of lead.

**LEAD SERVICE LINE INFORMATION FOR R5 WEBSITE**

http://www.epa.gov/r5water/

**Ground Water & Drinking Water**

1. Drinking Water Quality
2. Underground Injection/Subsurface Disposal of Fluids
3. Motor Vehicle Waste Disposal Wells
4. Lead Service Lines and Drinking Water

**Ground Water & Drinking Water>Lead Service Lines**

[Main Page]

**Page title: Lead service lines and drinking water**

In 2011, EPA Region 5 and the City of Chicago conducted a study on lead sampling. They made a number of important findings about lead sampling and lead service lines. [Assessment of Varying Results from Alternative Field Sampling Protocols for Lead in Drinking Water ⊠ linked to the Environmental Science and Technology Journal website (ES&T website link)]

This website presents additional information for consumers and public water systems on lead service lines based on the study and other findings.

[links]
1. What are lead service lines?
2. What are public water system (PWS) responsibilities?
3. How do I know if I have a lead service line?
4. Should I be concerned if my home has a lead service line?
5. What is the "lead action level"?
6. What can I do to reduce lead levels if I have a lead service line?

---

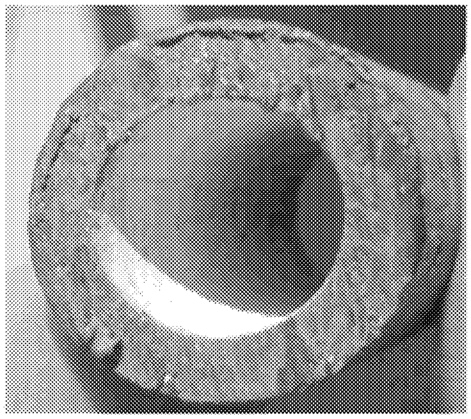
**What are lead service lines?**

Service lines are underground pipes that connect your home to the municipal water mains and bring the drinking water into your home.

Lead was commonly used as service line pipe material beginning in the late 1800s. The use of lead pipes was widespread because lead pipes last much longer than pipes made of other material and require less maintenance. Lead service lines were still being installed as recently as the early 1980s in some cities and towns. In some cities and towns, the use of lead pipe was required. In others, lead pipe was not required but still used.

Lead in drinking water almost always comes from lead pipes, leaded-solder and leaded-brass fittings and fixtures. Lead service lines are the single largest source of lead in residential drinking water (Sandvig, etal. 2008).

**What are public water system (PWS) responsibilities?**
Community water systems such as cities and towns, and non-transient non-community water systems such as schools with their own water supply are required to minimize lead levels in drinking water. Most of these water systems with lead service lines provide treatment to minimize the amount of lead in drinking water by:



- changing the water chemistry to make it less corrosive toward lead
- adding a corrosion control chemical to form a protective layer (scale) inside of the lead service lines (see picture)

Although treatment can significantly lower lead levels, it is not possible to completely eliminate lead from the drinking water where there are lead service lines. There will always be a residual amount of lead in the water.

If the treatment provided by the water system is ineffective or not adequately maintained, lead levels in drinking water can increase significantly. Lead levels can also increase to very high levels if the protective scale within the lead service line is disturbed which can be dangerous, especially to infants, children and pregnant women.

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**How do I know if I have a lead service line?**

In many cities and towns, the entire service line or a portion of the service line is made of lead pipe. The length of the lead pipe and the location of the lead pipe can be different in different cities and towns and even among homes in the same city or town.

In 1990, a study estimated that there were 3.3 million lead service lines in the U.S. as well as an additional 6.4 million lead connections, commonly known as *lead goosenecks* (Weston and EES 1990). A lead gooseneck is a short lead pipe that connects the water main to the service line. The actual number of homes with a full or partial lead service line in the U.S. is unknown. Many cities and towns have reported that they did not know if they have lead service lines.

In 1986, the Safe Drinking Water Act banned the installation of new lead pipes nationally, but existing lead service lines were not required to be removed. Public water systems stopped using or allowing lead pipes at different points in time, so the number of lead service lines and the location of the lead service lines within a city or town can vary considerably.

To find out if you have a lead service line, you can:

- Inspect your own service line;
- Call your water provider to ask if any portion of your service line is made of lead; or
- Call a licensed plumber to inspect your service line.

More information on how to inspect your own service line [Link to PDF/Webpage 1]

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**<u>Should I be concerned if my home has a lead service line?</u>**

**Lead can get into your drinking water.**

If your home has a lead service line, you will have lead in your drinking water. The lead gets into the water in a few ways including:

- from particles and sediment which can contain very high levels of lead that can accumulate in your home plumbing and can be released into the drinking water.
- by dissolving from within the lead pipe or other lead-containing plumbing components into the drinking water.

Lead levels in drinking water increase the longer the water sits in the lead pipes without being used.

***Residents should especially be aware of any work that could disturb the lead service line. Lead can reach very high levels in your drinking water if the lead service line is disturbed, and can pose a danger to children and infants.***

**Lead is harmful to health, especially for children**

Lead exposure can have devastating effects on children, and affects the body in many ways. U.S. EPA and the Centers for Disease Control (CDC) have established that **there is no safe level of lead exposure.**

While paint, dust, and soil are the most common sources of lead, drinking water can contribute 20 to 40 percent of an infant's lead exposure, and it is important to know that even exposure to low levels of lead can severely harm children.

Lead is especially dangerous to children under age six. Children's brains and nervous systems are more sensitive than adults are to the damaging effects of lead. Children's growing bodies absorb more lead during this time. In addition, Women with a high lead level in their system before or during pregnancy risk exposing the fetus to lead through the placenta during fetal development.

Infants, children and pregnant women should avoid all lead exposure because some neurological damage that lead can cause is permanent and irreversible. Lead can have adverse health impacts on adults, as well.

*For More Information on Lead Health Effects*

- EPA Website on Lead (http://www2.epa.gov/lead)
- Centers for Disease Control and Prevention (CDC) on Lead (http://www.cdc.gov/nceh/lead/

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**What is the "lead action level"?**

The EPA lead action level is commonly mistaken for a health-based limit, and has resulted in confusion for the public in understanding the health effects from lead.

EPA's action level for lead in drinking water, which is set at 15 parts per billion (ppb), is only a regulatory trigger level. If the 'action' level is exceeded, public water systems must take additional ***actions*** specified by the Lead and Copper Rule, such as installing treatment, providing educational material on lead to consumers, and replacing lead service lines.

***The lead action level of 15 ppb is not based on health effects***. It should not be used as a guide to determine whether your water is safe or unsafe to drink when lead levels are above or below this number.

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**What can I do to reduce lead levels if I have a lead service line?**

U.S. EPA and CDC have established that there is no safe level of lead exposure. The **goal** is to remove as much lead from your drinking water as possible. The following recommendations will help you reduce exposure to lead in drinking water.

[#s 1-8 are links to the sections lower down in the page]

- Have your water tested
- Be aware of any work that could disturb your lead service line
- Run water before use if it has not been used for several hours
- Use only cold water for drinking, cooking and preparing baby formula
- Purchase a water filter that is certified to remove 'total lead'
- Periodically clean your faucet aerators
- Purchase lead-free faucets and plumbing components
- Remove the entire lead service line

**Have your water tested**

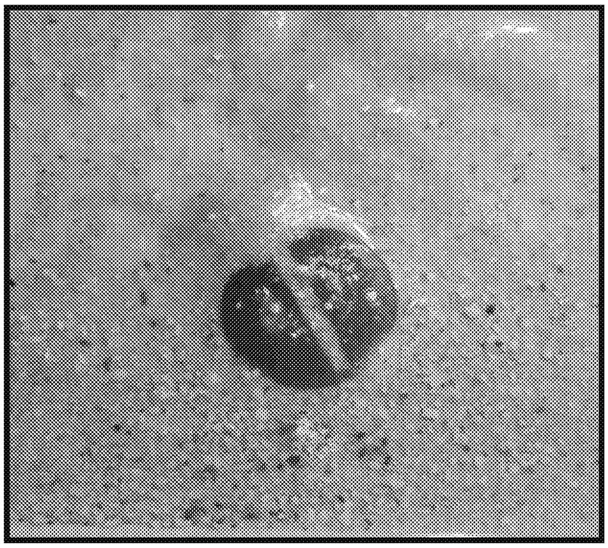
Many public water systems will test your water for free. Contact your water system to see if they offer free home testing.

If your water system does not offer free testing, ask for a list of laboratories certified in your state to analyze drinking water samples. Most state drinking water program websites offer a list of laboratories that are certified to perform drinking water analyses. Laboratory services and costs vary, so call several laboratories to compare the costs and services offered.

If you would like to test your water, there is additional information you should know about collecting your sample and what your results will mean.

Water testing information and instructions [LINK TO PDF/Webpage 6]

**Be aware of any work that could disturb your lead service line**



If you use water in your home after your lead service line is disturbed, the particles and sediment that came loose from the inside of the lead service line can contain dangerously high lead levels and can come into your home plumbing and drinking water (see picture).

Anytime your lead line is disturbed, you should follow the flushing instructions to flush the particles and sediment out of the plumbing. Avoid bringing the lead-containing particles and sediment into your home plumbing.

The small particles and sediment that come loose from the lead service line can contain a dangerously high lead content. In this photograph, the particles that came loose after a lead service line leak repair contained over 300,000 micrograms per liter (parts per billion) of lead and the water containing the suspended sediment contained over 100,000 micrograms per liter (parts per billion) of lead.

Your lead service line can be disturbed in many ways, such as:

- water main replacement
- lead service line leak repair
- replacement of a portion of the lead service line (called partial lead service line replacement)
- installation or repair of a water meter
- significant excavation in the street in front of your home

Homes where water use is low can also have higher lead levels. Although the exact reasons are not known, it may be because when less water is used, less of the treatment chemical used by the public water system to form a protective coating in the lead service line flows through the service line and there is also some research suggesting that the corrosion control chemicals may be less effective under low water use conditions.

Residents should also run the water before use if it has not been used for several hours. The more time water has been sitting in your home's pipes, the more lead it may contain. This is true even if you do not have a lead service line. However, the amount of time you should run the water to flush the lead out depends on whether you have a lead service line or not.

Flushing instructions for residents [Link to PDF/Webpage 3]

**Use only cold water for drinking, cooking and preparing baby formula**

Use only water from the cold-water tap for drinking, cooking, and especially for making baby formula. Hot water is likely to contain higher levels of lead.

**Purchase a water filter that is certified to remove 'total lead'**

A water filter that is certified to remove lead can effectively remove up to 99 percent of the lead from the water and may be a cost-effective alternative to removing the lead service line. Water filters can also help to conserve water by eliminating the need to flush the taps when water has not been used for an extended period of time.

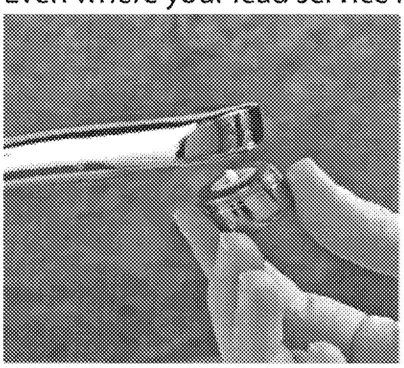
You should purchase a filter that is certified to remove 'total lead'. Total lead includes lead that has dissolved into the water as well as lead particles that may have come loose from the plumbing. You should use a water filter that is certified against either NSF/ANSI Standard 53 or 58 for 'total lead' removal and follow the manufacturer's instructions for replacing the filter cartridges.

To find a water filter that is certified to remove lead, you can visit the following webpages:

- National Sanitation Foundation [Link to: http://www.nsf.org/certified/consumer/listings_main.asp ]
- Water Quality Association [Link to: http://www.wqa.org/ ]

**Periodically clean your faucet aerators**

Even where your lead service line has not been disturbed, lead particles and pieces of lead-containing scale occasionally come loose from the lead service line and can become trapped in the faucet aerators.





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You should remove and clean any debris from the aerators on a regular basis to clear out any particles that may become trapped in the aerator.

Periodically remove your aerator(s) and clean them to clear any lead particles that may become trapped.

Instructions on cleaning your aerator [LINK to PDF/Webpage 4]

**Purchase lead-free faucets and plumbing components**

Many faucets, fixtures and fittings that are made of brass can contain a significant amount of lead which can enter the drinking water. You should purchase plumbing components that are certified as lead-free.

On January 4, 2014, a new federal law will take effect in the U.S. requiring plumbing products to meet a lower lead limit.

- Affects all plumbing products sold for potable water use in the home
- New lower lead limit (0.25 percent lead on the wetted surface)

Many plumbing manufacturers' products already meet the new federal 0.25 percent lead standard, because California and Vermont already passed similar laws to the federal law that will become effective nationally in January 2014.

**Remove the entire lead service line.**

The best solution, where possible, is to have the lead service line removed completely. Fully removing all portions of the lead service line provides the best reduction of lead levels in the water.

Under the Lead and Copper Rule, when water systems with lead service lines exceed the EPA's lead 'action level', they are required to replace 7 percent of the total number of lead service lines in the water system unless the lines have lead levels below 15 micrograms per liter (parts per billion) in all samples collected from the lead service line.

The water system is only required to replace the portion of the lead service line owned by the water system, but the water system must offer to replace the homeowner's portion of the line at the same time, at the homeowner's expense. If the homeowner agrees to pay, the homeowner's portion of the lead service line must be removed by the water system. If the homeowner does not agree to pay the cost, the homeowner's portion of the lead service line is not required to be replaced by the water system.

The portion of the service line owned by the water system is usually from the water main to the property line or external shut-off valve. In some places, homeowners own the entire service line from the water main to the home and are responsible for paying to remove the entire service line. You may contact your water system for information specific to your location.

Some public water systems also have voluntary lead service line replacement programs.

Replacing only a portion of the lead service line may actually increase lead levels in the drinking water for an unknown period of time, especially immediately after a portion of the line is removed. This is mostly due to the protective scale falling off and water contacting the lead pipe directly. In addition, a dielectric union or connector should be used to connect the lead and copper or iron pipes to minimize galvanic corrosion.

More information on lead service line replacement [LINK to PDF/Webpage 2]

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**Where Can I Find More Information?**

More information on lead:
[http://www2.epa.gov/lead]

Protect Your Family from Lead in Your Home (English, Spanish, Vietnamese, Russian, Arabic, Somali)
[Link to http://www2.epa.gov/lead/protect-your-family-lead-your-home-real-estate-disclosure]

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**Who can I contact if I have more questions?**

If you have questions regarding the lead study, lead service lines, or testing your water for lead, you can call or email Miguel Del Toral at (312) 886-5253 or deltoral.miguel@epa.gov

# Detection and Evaluation of Elevated Lead Release from Service Lines: A Field Study

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|---|---|
| Journal: | *Environmental Science & Technology* |
| Manuscript ID: | es-2013-003636.R2 |
| Manuscript Type: | Article |
| Date Submitted by the Author: | n/a |
| Complete List of Authors: | Del Toral, Miguel; U.S. EPA Region 5, Ground Water and Drinking Water Branch<br>Porter, Andrea; U.S. EPA Region 5, Ground Water and Drinking Water Branch<br>Schock, Michael; U.S. EPA, ORD, NRMRL, WSWRD |
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# Detection and Evaluation of Elevated Lead Release from Service Lines: A Field Study

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Keywords: Lead service line [LSL]; tap water; drinking water; Lead and Copper Rule [LCR]; lead sampling; lead in drinking water.

# Detection and Evaluation of Elevated Lead Release from Service Lines: A Field Study

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## ABSTRACT

Comparative stagnation sampling conducted in 32 homes in Chicago, Illinois with lead service lines demonstrated that the existing regulatory sampling protocol under the U. S. Lead and Copper Rule systematically misses the high lead levels and potential human exposure. Lead levels measured with sequential sampling were highest within the lead service lines, with maximum values more than four times higher than Chicago's regulatory compliance results using a first-draw sampling protocol. There was significant variability in lead values from different points within individual lead service lines and between different lead service line sites across the city. Although other factors could also influence lead levels, the highest lead results most often were associated with sites having known disturbances to the lead service lines. This study underscores the importance and interdependence of sample site selection, sampling protocol and other factors in assessing lead levels in a public water system.

## Introduction

***Background.*** Most lead in drinking water comes from premise plumbing materials and lead service lines (LSLs). LSLs are generally the largest source of lead in drinking water when they are present in public water systems.[1] The 1986 Safe Drinking Water Act Amendments banned new lead pipes in the potable water network, but a legacy of millions of partial or whole LSLs remains in many public water systems.[2] Where the term 'lead corrosion' is used, it refers to the corrosion of lead plumbing materials that result in the transfer of dissolved or particulate lead into the drinking water.

The Lead and Copper Rule (LCR) sampling is intended to measure the lead levels in drinking water to assess the effectiveness of corrosion control treatment utilized by public water systems (PWSs) to minimize lead in drinking water. PWSs are required to use sampling sites that are presumed to be the highest-risk sites for lead release, and to optimize corrosion control to minimize lead levels at consumers' taps. Most published sampling studies typically focus on systems having high lead levels or systems that have experienced challenges in attempting to balance LCR compliance with various other treatment or water quality objectives. Except for LCR compliance data, little published data exists or is available for systems that are considered to be operating with optimal corrosion control and meeting the lead action level (AL) in the LCR. This study focuses on a system that is considered to have optimized corrosion control using a blended phosphate, with a relatively stable water quality, and compliance results historically well below the lead AL. This situation is generally more representative of most public water systems in the U.S., since the majority of systems utilize orthophosphate or blended phosphates for corrosion control and the vast majority of systems are meeting the lead AL based on the current sampling protocol in the LCR. Additional information on the LCR and study is available in the supplemental information section as indicated by [SI-Table/Figure x]. This study focused on whether: 1) the current LCR compliance sampling protocol adequately captures the peak lead levels in a water system; 2) 'pre-flushing' (PF) results in capturing lower lead levels in samples compared to samples collected under normal household usage (NHU) conditions; 3) a first-draw sampling protocol appropriately determines the adequacy of optimal lead corrosion control in water systems with LSLs; and 4) whether there is seasonal variability in the sampling results using the different sampling protocols.

***System information.*** The Chicago Department of Water Management (CDWM) operates two similar conventional surface water filtration treatment plants serving approximately 5.4 million residents, which includes 125 suburbs. Lake Michigan is the sole water source, with relatively stable water quality leaving the treatment plants and in the distribution system. (Table 1) Before the LCR, CDWM utilized pH/alkalinity adjustment for corrosion control. CDWM switched to a proprietary blended phosphate at both plants between 1993 and1994 which is still used as the primary corrosion control treatment.

The LCR requires public water systems to collect lead samples using a first-draw (FD) sampling protocol and samples were collected almost exclusively from single-family homes with LSLs as required by the LCR sample site selection requirements.[3] Since the initial LCR monitoring, Chicago has exceeded the lead AL only once, during July-December 1992, with an average $90^{th}$ percentile compliance monitoring value between 1999 and 2010 of 6 µg/L [SI-Table S2].[3]

The LCR requires one liter, FD tap samples of water that has stood motionless in the plumbing system (i.e., has stagnated within the plumbing) for at least six hours. The two variants of the FD sampling protocol currently used by public water systems are defined herein as the NHU first-draw sample, where water is used in a normal household manner, and then allowed to sit motionless in the plumbing for at least six hours before the sample is collected; and the PF first-draw sample, where the water is run from the sampling tap for a specified amount of time immediately prior to the stagnation period. However, the LCR does not provide specific details on water use during the stagnation period.

Almost all PWSs in the U.S. rely on residents to collect compliance samples under the LCR and there are differences across the U. S. in how systems instruct residents not to use the water during the stagnation period prior to collecting the sample. A review of example sets of sampling instructions provided to residents by large PWSs in the U.S. found that some are instructed not to use any water *from the tap to be sampled* during the stagnation period. Others are instructed not to use *any water in the household*. Prior to 2009, CDWM used the PF first-draw sampling protocol, with a 5 minute pre-flush preceding stagnation. Recent instructions to residents included not using water from the sampling tap or from any nearby tap until the (post-stagnation) samples were collected, and to collect samples as soon as possible after the minimum required six hour stagnation period. Regardless of the sampling protocol, resident-collected samples necessitate the use of simple instructions and make it difficult to assure strict adherence to any sampling protocol. In addition, the diverse premise plumbing materials and configurations [SI-Table S1] represent varying effects of flow rates, hydraulic flow characteristics, and possible lead sorption/particle release effects on the shapes of the lead profiles, particularly with corroded galvanized pipe locations.[4, 5]

## Materials and Methods

***Sampling objectives and protocol.*** Since the promulgation of the LCR, new research on lead corrosion has shown that there are many mechanisms and water quality factors involved.[1, 4, 6-11] Specifically, the sampling protocols used in this study were evaluated to determine if:

- pre-flushing biases results;
- first-draw samples, with or without pre-flushing, capture the "worst-case" level of lead corrosion under normal use conditions; and
- seasonal variability affects lead concentrations (in this water system).

Consistent with the LCR requirements and CDWM compliance sampling, samples for this study were collected by volunteer residents from 32 single-family residences, built between 1890 and 1960, with LSLs. An additional five homes were sampled and determined not to have LSLs, and were therefore excluded from further sampling. All results are included in the supplemental information, but the non-LSL sites were not used in the data analysis [SI-Tables S4a, S5, S6a, S6b and S7].

Information was requested on the specific plumbing configurations of each sampling site to a much greater extent than the regulatory requirements which simply require the plumbing material to be identified. This information, along with analyses conducted for lead, copper, iron and zinc for each sample, facilitated a better understanding of the observed water lead levels. Residents were asked to: 1) complete a plumbing profile identifying the kitchen tap and meter or internal shut-off valve; and 2) describe the internal plumbing, including any recent plumbing work [SI-Figure S1]. The information provided by residents along with the results of the four metals provided additional information on the sequences of plumbing materials, and the presence of in-line brass plumbing components. CDWM provided the location of water mains, service line materials, work conducted by the city at each residence (meter installation or repair, shut-off valve repair/replacement, service line leak repair, street excavation), and monthly water use data for residences with water meters. The information provided by CDWM on water main locations was used to measure the distance from the water main to each residence and internal plumbing information provided by residents was used along with the measured length from the water main to the residence to approximate the LSL length [SI-Table S1].

Residents were provided with written sampling and reporting instructions for each sampling event [SI-Figures S41-S45]. One-liter high density polyethylene (HDPE) wide-mouth (5.5 cm, 2.2 in) sample bottles were used to collect all samples. Residents were instructed not to remove aerators prior to sampling and not to collect samples after point-of-use or point-of-entry treatment devices.

Several prior studies have suggested that significant contributions of particulate-associated lead can be mobilized as a function of flow rate and turbulence in certain water chemistries, though studies have not developed predictive relationships to premise plumbing material, scale composition, and hydraulic flow characteristics.[6, 10-15] To try to achieve the most aggressive high flow conditions under realistic field conditions, residents were instructed to collect all samples by slowly opening the cold water kitchen tap until fully open. Upon receipt, the samples were inspected by EPA for visible particulate matter prior to delivery to the laboratory.

For all first-draw samples, residents were instructed not to use any water throughout the household (i.e., no showering, washing clothes/dishes, flushing toilets, etc.) during the minimum mandatory 6 hour stagnation period. In this study, PF samples include a flush of at least 5 minutes prior to the mandatory minimum six-hour stagnation period. A NHU sample had no pre-flushing prior to the mandatory minimum stagnation period. Residents were instructed to allow the water to sit motionless in the household plumbing a minimum of 6 hours, but not more than 24 hours and to record the dates/times the taps were flushed prior to the stagnation period, and the dates/times samples were collected following the stagnation period. First-draw samples using both variants (NHU and PF) were collected in the first and third rounds of monitoring in March/April and September/October, respectively. Additionally, 45-second flushed samples were collected in the first round to evaluate whether a second-draw sample more accurately captured the level of corrosion. Three-minute, five-minute, and seven-minute flushed samples were collected in the third round of sampling to provide guidance to volunteers when high lead levels were found [SI-Table S7]. This information can also be used to provide site-specific guidance on minimum flushing times necessary to reduce consumer exposure to lead in drinking water.

In the first round of sampling, each resident collected a NHU first-draw sample and then a second-draw (45-second flushed) sample after allowing the water to run for 45 seconds. On the second day, residents collected a PF first-draw sample and then a second 45-second flushed sample. EPA's current Public Notification Handbook advises residents to run the water 30 seconds or until it turns cold before consuming, if the water has not been used for an unspecified 'extended period of time', which can result in higher lead levels at the tap for consumers. It has also been previously demonstrated that in some situations, this advice can cause residents to consume the worst-case water sitting stagnant in the LSL.[16, 17] (Figure 1)

Sites 14, 15, 16 and 37 were verified as not having LSLs and were excluded from further sampling. Site 2 was verified as not having a LSL following the June sequential sampling and was excluded from the final round of monitoring. The 45-second flushed sampling was discontinued following the March/April sampling first round due to the presence of severely corroded galvanized pipe in some of the residences [SI-Figure S4] which reduced the inner pipe diameter, restricting water flow and resulting in varying volumes of water flowing through the plumbing for the same flush time.

In June 2011, each resident collected a total of twelve PF sequential samples in one day of sampling. The first PF sequential sample was also the PF first-draw sample for the data analysis. All samples were analyzed for lead, copper, zinc and iron. The co-occurrence of the metals, along with plumbing details, was used in qualitative assessments to correlate lead results with potential sources of lead in the plumbing network [SI-Figure S6].[4, 10]

In September/October 2011, each resident collected a NHU first-draw sample, and a minimum of 11 PF sequential one-liter samples. Sites with high lead levels in the previous rounds collected an additional 3 or 4 PF sequential samples and one site with a very long LSL (157 ft, 48 m) collected an additional 9 PF sequential samples. The additional PF sequential samples were collected to determine the point at which lead levels consistently dropped below the AL. All samples collected are included in the sampling summary with the numbers and types of samples collected at each site [SI-Table S3].

Most stagnation times were relatively consistent across most sites at between 6 and 8.5 hours, and all but two sites had stagnation times between 6 hours and 9 hours 10 minutes, which facilitated unadjusted comparisons [SI-Table S6c].

Additional flushed samples were collected in September/October for high lead sites in order to provide residents with guidance on minimizing lead levels in their drinking water.

Recommended minimum flushing times were then estimated based on the lead levels and LSL lengths. These results are included in the supplemental information, but not discussed here.

***Sample Analyses.*** All samples were visually inspected for particulate matter prior to delivery to the EPA Chicago Regional Laboratory. Samples were preserved upon receipt by the laboratory using concentrated nitric acid to pH <2 and held for a minimum of 24 hours prior to analysis.[18] The Laboratory's Reporting Limits (RL) for lead, copper and zinc in drinking water samples, using EPA Method 200.8 are 0.5 μg/L, 1 μg/L and 10 μg/L, respectively. The Laboratory's RL for iron in drinking water samples, using EPA Method 200.7 is 80 μg/L. Additional laboratory information is included in the supplemental information.

**Results and Discussion**

***Both variants of the first-draw protocol significantly underestimated peak lead levels, and the NHU first-draw protocol yielded higher results overall than the PF first-draw protocol.*** The 90$^{th}$ percentile lead values for all three rounds of first-draw sampling using both variants were slightly higher than Chicago's historical compliance results, but still fell well below the lead AL [SI-Table S4b]. Only 2 percent of the total number of first-draw samples (3 of 151) exceeded the AL despite the presence of lead levels well above the lead action level within the service lines as indicated by the 45 second flushed results in the first round of monitoring and sequential sampling results in the second and third rounds.

In contrast, if the 90$^{th}$ percentile value of each of the successive sequential liter samples from the LSLs is computed across all sampling sites, the lead levels were up to four times higher than the Chicago's average 90$^{th}$ percentile value using FD samples. Some peak values for each sequential liter calculated across all sampling sites were over twice the lead AL and up to six times higher than the regulatory compliance data. (Figure 2) In summary, 69 of 336 (21%) of the individual sequential samples collected in June and 75 of 319 (24%) of sequential samples in September/October exceeded the lead AL, indicating that current sampling protocols will often considerably underestimate the peak lead levels and overall mobilized mass of waterborne lead in a system with lead service lines.

The NHU results were numerically higher overall than the corresponding PF values for most sites, but the differences were not statistically significant. The PF first-draw protocol produced lower individual results than NHU first-draw protocol in 23 of 32 sample pairs in March/April, and 20 of 27 sample pairs in Sept/Oct [SI-Table S4b]. Although NHU first-draw samples were collected without directing the residents to flush the tap prior to the stagnation period, NHU can involve showering, washing dishes or doing laundry a short time prior to the stagnation period, which could clear the lead from the pipes similar to pre-flushing the tap. Thus a NHU sample can effectively be the same as a PF sample and yield similar results. Since the sequential sampling results from these same sites show that there is much higher lead present within the LSL at the same time that the NHU and PF first-draw samples were collected, it stands to reason that if the NHU activities were not undertaken, and a larger sample set were used, the NHU results would yield results that were statistically higher than the corresponding PF samples. The distance from the kitchen tap to the beginning of the LSL was highly variable, ranging from approximately 3 feet to 87 feet (0.9 to 27 m), and the measured LSL lengths ranged from 43 feet to 159 feet (13 to 48 m). Consequently, for sites with shorter total plumbing lengths, the initial and final sequential samples would include relatively uncontaminated water from the water main following the 5 minute tap pre-flushing. These samples would contain little to no LSL lead contribution, consistent with plumbosolvency and radial diffusion/flow principles.[5, 19, 20] A targeted LSL sampling protocol isolating only LSL contact water would likely yield a higher percentage of results above the lead AL for systems with Pb(II) pipe scale chemistry, but the specific location of the peak lead levels will necessarily vary with premise plumbing configurations.

***Seasonal variability.*** In a site by site comparison, lead concentrations were higher in Sept/Oct than in Mar/Apr or June, with the starkest statistical difference between first-draw NHU samples collected in Mar/April and Sept/Oct ($p=0.03$ for two-tailed paired Student's t-Test). Overall, 68% and 69% of NHU and PF first-draw samples, respectively, were higher in Sept/Oct than in Mar/Apr, while 55% of paired sequential samples were higher in Sept/Oct than in June. Seasonal variation in lead levels consists of multiple contributing factors from the source water through the premise plumbing which could not be precisely isolated in this study, but the results in this study are consistent with other findings on seasonal variability [SI-Table S6d].[21] Factors include: 1) water temperature; 2) water chemistry variation; and 3) fluctuations in water usage for Sept/Oct versus June, which could increase or decrease lead levels.[22, 23]

***Lead concentrations vary throughout each individual LSL and among different LSLs across the system.*** There was a high degree of variability in sequential sample results at most sites, some of which could include a particulate-bound component as reflected in spikes in some sequential sampling results. (Figure 3) For most sites, no individual sample result from within the LSL can *characterize* the lead concentrations at the site. Within the complete sampling profile results, lead levels at most sites ranged from well below to well above the AL [Figures

S9-S45]. Under the LCR, this would mean that a system would meet the action level and have no additional regulatory requirements or would exceed the AL and be required to implement additional requirements, depending on which sample result is selected as the compliance sample. The variability within sites and between sites is similar in trend to that found in several other studies reporting sequential sampling conducted in water systems with different corrosion control strategies and chemistries from CDWM.[1, 4, 10, 12, 14, 15, 24-27]

Additional compliance data from a second large utility (City B) which exceeded the lead AL and conducted sampling using the temperature change LSL sampling protocol in the LCR,[3] yielded similar variability across the system [SI-Figure S8 and Table S9]. A total of 1975 LSL sites were sampled, with 1,762 results (89%) below the lead AL; 128 results (6.5%) from 16 to 30 µg/L; 57 results (2.8%) from 31 to 50 µg/L; and 28 results (1.4%) between 51 and 580 µg /L. This LSL sampling protocol is similarly vulnerable to low biases, although many results were considerably higher than the AL [SI-Figure S7].

***Factors affecting lead levels.*** The majority of high lead results occurred at sites with a documented physical disturbance of the LSL between 2005 and 2011. (Figure 4) The actual extent to which the LSL was physically disturbed is unknown for all sites, and the records of disturbances are based on information provided by CDWM and by the sampling volunteers [SI-Figures S9-S40].

For the purpose of this study a physical LSL disturbance is defined as a meter installation or replacement; auto-meter-reader (AMR) installation; service line leak repair, external service shut-off valve repair or replacement, or significant street excavation directly in front of the home that could disturb the LSL. An 'undisturbed' site is an un-metered site where neither the CDWM nor resident have a record or recollection of any disturbance, as defined above. A third category 'indeterminate' is used for three sites where CDWM has no record of any LSL disturbance, and the resident did not provide a response as to whether there has been any LSL disturbance. Cross-checking was important because information provided by volunteers in some cases contradicted CDWM records, and upon further investigation, the records were found to be incomplete and were corrected, which resulted in reclassification of the site.

Of the 13 disturbed sites, 11 sites had 3 or more sequential sampling results above the lead AL, two sites had 2 results each above the AL, and one site had no results above the AL. Of the 16 sites with no known disturbance, only three sites had any results above the lead AL. In the remaining 3 'indeterminate' sites, 30 of 81 sample results (37%) were above EPA's lead AL. (Table 2)

A recent AWWA publication on the state of water infrastructure highlights the need for major infrastructure work.[28] This necessary infrastructure work will potentially increase the incidence of damage to the protective scales within LSLs as this work is performed. Inevitably, these physical LSL disturbances will continue to occur with increased frequency as part of daily routine water system maintenance and non-water related community infrastructure work.

***Possible implications of water conservation and use.*** Information provided by CDWM and volunteers anecdotally suggests that low water usage may also play a role in high lead levels at some sites. Of the four locations with the highest average lead levels, three (Sites 1, 29, and 10) had documented low water usage. Site 1 had average monthly water usage of 3,444 gallons (13,037 L) which does not appear to be low usage. However, information provided by the resident indicates that the majority of the monthly water usage occurs during a relatively small number of days during the month when there is a high volume water usage. Site 29 had average monthly usage of 1,826 gallons (6,912 L), and Site 10 had an average usage of 1,438 gallons/month (5,443 L/month). For comparison, the mean single-family household water usage is approximately 8,582 gallons/month (32,486 L/month), with a sizable standard deviation.[29]

In two locations (Sites 17 and 5), lead levels decreased with an increase in water usage. As water usage approximately doubled at Sites 17 and 5, maximum lead levels from sequential sampling decreased from 25 to 5.5 μg/L and from 17 to 12 μg/L, respectively. Although this represents a small set of samples, these observations support the idea that higher lead levels can be associated with low water usage.[30]

Extrapolating from prior research that suggests the necessity of consistent flow to deliver corrosion inhibitor effectively into passivating films,[31] and that correlates increased inhibitor dosages with reduced lead release.[10, 32-35] Low water usage may inhibit healing of the damaged scales, and influence the rate of galvanic corrosion. Water usage effects cannot be separated from other *seasonal* effects in this study, but prior literature and the combined sequential graphs showing entire profiles shifted up or down from the June to Sept/Oct sampling suggest further investigation is warranted [SI-Figures S9-S40]. As conservation efforts increase, it will become increasingly important to conduct further research on the relationship between water usage and increases in lead levels.

The results in this study also indicate that more appropriate flushing guidance must be developed, based on neighborhood and premise plumbing characteristics, and whether a home has a LSL or not. Much of the current published and web-based flushing guidance inadvertently increases the risk of exposure to elevated lead levels by clearing an insufficient amount of water volume.[16] Even fully-flushing LSLs may only lower lead levels to a limiting, measurable lead level, that relates to the plumbosolvency of the water, the flow rate, the length and internal diameter of the pipe,[5-7, 10, 19, 20] and possibly effects of prior disturbances [SI-Table S7].

***Risk identification and management.*** Recently, CDC issued a health alert associating higher elevated blood lead levels with partial LSL replacement,[36] and also concluded that LSLs were an independent risk factor for elevated blood lead levels even when lead levels in drinking water met the LCR lead AL of 15 μg/L.[37] As highlighted in this study, LSLs can contribute high lead when they are disturbed in many different ways, not just due to partial LSL replacement, and water usage may also play a role in the resultant high lead levels and potential increased human exposure. In an August 2012 update on lead in drinking water and blood lead levels, the CDC notes that *"The recent recommendations from the CDC Advisory Committee on Childhood Lead Poisoning Prevention to reduce or eliminate lead sources for children before they are exposed underscore the need to reduce lead concentrations in drinking water as much as possible"*.[38]

As the ultimate human and environmental health goal, LSLs should be completely removed where possible. The stability of the protective scales within LSLs depends on many factors which can change over time. For example, changes to water quality or treatment have resulted in high lead levels over a sustained period of time (years).[10, 39-41] Under the current regulatory framework, elevated lead levels from disturbances, water quality, treatment, or water usage changes can potentially go undetected for up to three years between LCR compliance monitoring periods, which can result in increased public exposure over a significant period of time.

Proper selection of sampling sites, sampling protocol, and other site conditions are critical for evaluating the amount of lead corrosion and release that is occurring in the distribution system. Successful optimization of the plumbosolvency treatment depends on an accurate understanding of the corrosion mechanisms, pipe scale mineralogy and structure, and the consequences of LSL disturbances and water conservation efforts. No published studies could be found that systematically investigated the time and inhibitor doses/water quality adjustments necessary to overcome the disturbances and damage to the lead pipe scales that will be routinely occurring throughout cities across the U.S., as long as full or partial lead service lines remain in service.

Analyses of the Chicago LSL scales by EPA (to be reported elsewhere) reveal that the surface coatings on both lead service line and galvanized interior pipes from CDWM are primarily composed of amorphous aluminum, calcium and phosphorus-rich deposits, and not crystalline lead(II) (or zinc) orthophosphate – phases that are predicted by conventional divalent lead plumbosolvency theory for orthophosphate dosing.[10, 33, 42] An understanding of the scales is essential to study and implement procedures and strategies for effective and timely repair of the protective scales damaged by LSL disturbances, and to minimize the public's exposure to high lead levels that can result from damaging the scales. Experimental evaluations are critical when scale compositions fall outside the scope of well-understood predictive corrosion control practices.

**Acknowledgments**

The authors wish to express special thanks to the City of Chicago Department of Water Management for the considerable time and effort put forth in providing information for this project and to the EPA and HUD volunteers who participated in this study and opened up their homes to make this project possible, as well as the team at the EPA Chicago Regional Laboratory for their work on the sample analyses, and Mostafa Noureldin (EPA) and Kevin Sui (Northwestern University) for their valuable assistance during this project.

**Disclaimer**

Any opinions expressed in this paper are those of the author and do not necessarily reflect the official positions and policies of the EPA.

**Supporting Information Available**

Additional background information, tabular summaries of sampling results and graphics are included in the supplemental information, free of charge via the Internet at http://pubs.acs.org.

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## Figure Captions

**Figure 1:** First round lead results for all sites.

**Figure 2:** Comparison of $90^{th}$ percentile LCR compliance data to $90^{th}$ percentile values from LSL samples (across sites by liter) and maximum values from LSLs. The green dashed line indicates the average $90^{th}$ percentile compliance monitoring value for Chicago between 1999 and 2010 of 6 µg/L.

**Figure 3:** LSL results were highly variable within each LSL and from site to site.

**Figure 4:** Average lead levels at disturbed and undisturbed sites. Error bars represent 1 standard deviation.

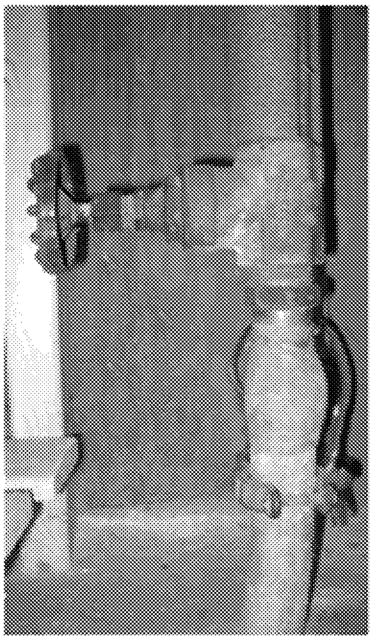
## Tables

| Water Quality (2011) | | | | |
|---|---|---|---|---|
| **Parameter** | **Outlets** | | **Distribution** | |
| | Min | Max | Min | Max |
| Temp (C) | 4 | 24 | 5 | 23 |
| Turbidity (NTU) | 0.1 | 0.2 | 0.1 | 0.4 |
| pH | 7.5 | 7.8 | 7.7 | 7.8 |
| $Cl_2$ Residual (mg/L) | 1.0 | 1.2 | 0.7 | 0.9 |
| Total Alkalinity (mg/L as $CaCO_3$) | 103 | 108 | 98 | 108 |
| Chloride (Cl, mg/L) | 16 | 20 | 17 | 20 |
| Sulfate (mg/L) | 29 | 31 | 29 | 30 |
| Ca (mg/L) | 34 | 39 | 34 | 39 |
| $PO_4$ (mg/L) | 0.4 | 0.6 | 0.5 | 0.5 |
| Total $PO_4$ (mg/L) | 0.8 | 1.1 | 0.8 | 1.2 |
| Al (µg/L) | 34 | 126 | 29 | 113 |
| Fe (µg/L) | <5 | <5 | <5 | 34 |
| Mn (µg/L) | <3 | <3 | <3 | <3 |

**Table 1:** Water Quality Data

| Disturbed Sites | | | Undisturbed Sites | | | Indeterminate Sites | | |
|---|---|---|---|---|---|---|---|---|
| No. Sites | No. Samples | No. above AL | No. Sites | No. Samples | No. above AL | No. Sites | No. Samples | No. above AL |
| 13 | 327 | 117 | 16 | 372 | 6 | 3 | 81 | 30 |
| **% samples over AL: 36%** | | | **% samples over AL: 2 %** | | | **% samples over AL: 37%** | | |

**Table 2:** Most lead results above the AL were found at sites with LSL disturbances. Additional results above the AL were also found at sites where the status of the LSL (disturbed or undisturbed) could not be confirmed. Sites without LSL disturbances had few if any results above the AL.



84x146mm (55 x 55 DPI)

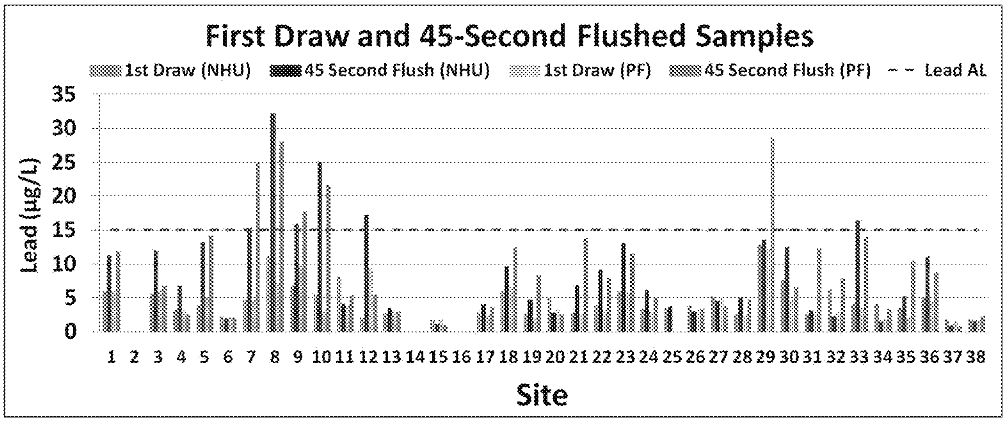



Figure 1: First round lead results for all sites.
142x59mm (300 x 300 DPI)

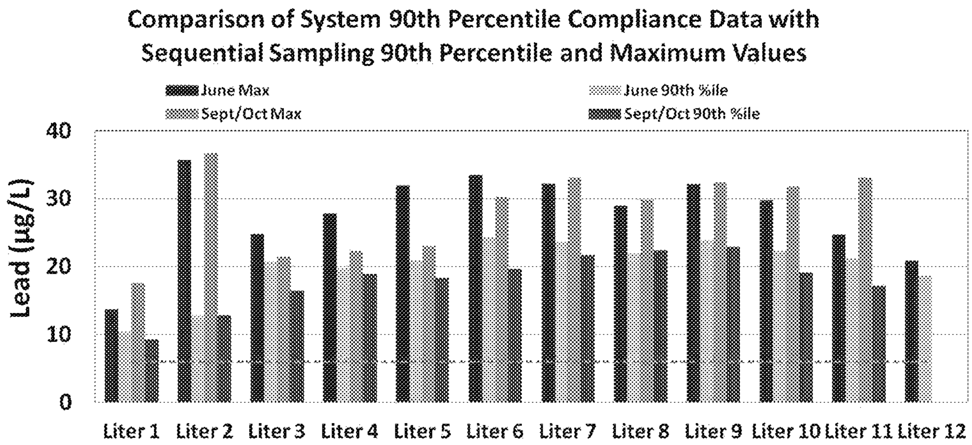



Figure 2: Comparison of 90th percentile LCR compliance data to 90th percentile values from LSL samples (across sites by liter) and maximum values from LSLs. The green dashed line indicates the average 90th percentile compliance monitoring value for Chicago between 1999 and 2010 of 6 ug/L.
140x66mm (300 x 300 DPI)

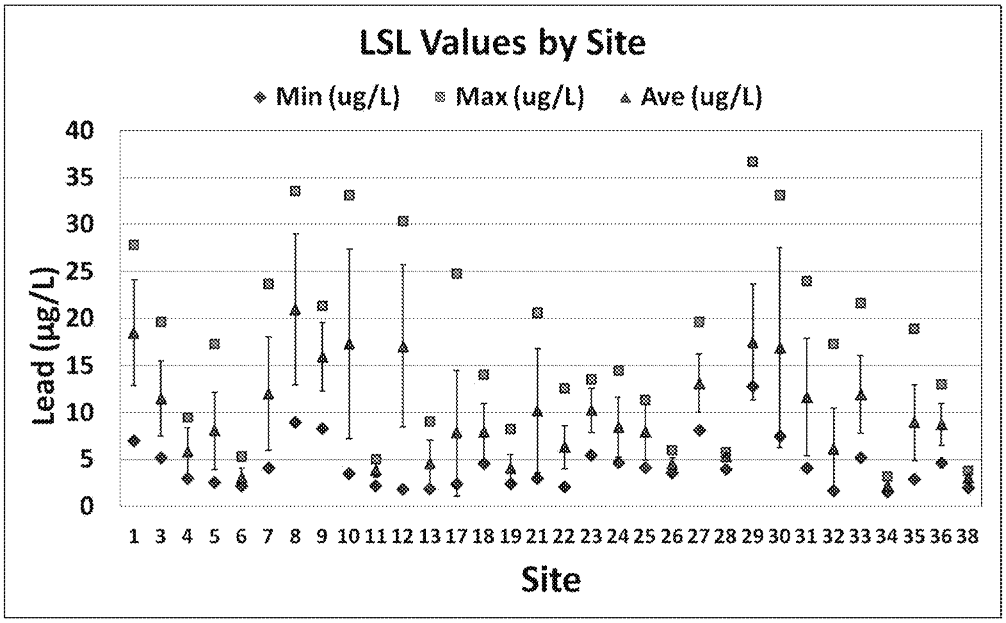



Figure 3: LSL results were highly variable within each LSL and from site to site.
123x76mm (300 x 300 DPI)

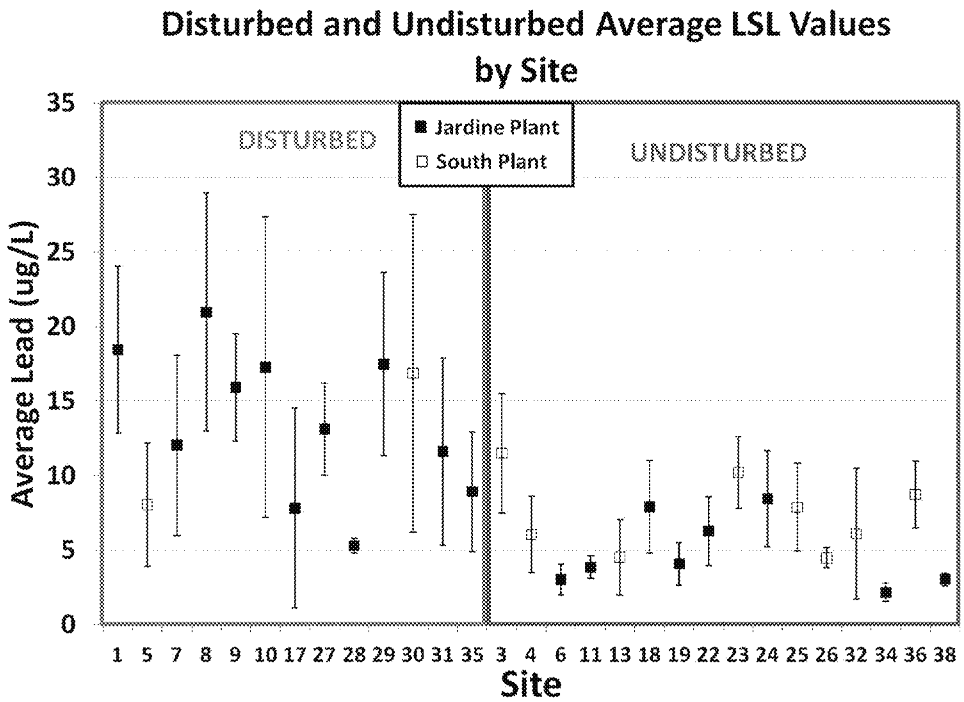



Figure 4: Average lead levels at disturbed and undisturbed sites. Error bars represent 1 standard deviation.
121x89mm (300 x 300 DPI)

# WATER TREATMENT CONTAMINANTS:

# TOXIC TRASH IN DRINKING WATER

**ENVIRONMENTAL WORKING GROUP**

FEBRUARY 2013

**www.ewg.org**

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**About EWG**
The mission of the Environmental Working Group (EWG) is to use the power of public information to protect public health and the environment. EWG is a 501(c)(3) non-profit organization, founded in 1993 by Ken Cook and Richard Wiles.

# WATER TREATMENT CONTAMINANTS:
## Too Much Toxic Trash in American Water

**BY RENEE SHARP, EWG SENIOR SCIENTIST
AND J. PAUL PESTANO, EWG RESEARCH ANALYST**

WATER TREATMENT PLANTS ALONG THE EAST COAST ARE STRUGGLING TO RECOVER FROM SUPERSTORM SANDY, WHOSE TORRENTIAL RAINS WASHED TENS OF MILLIONS OF GALLONS OF RAW OR PARTIALLY TREATED SEWAGE INTO WATERWAYS.

The less dramatic but equally urgent story: inside those waterworks, and others across the nation, chlorine, added as a disinfectant to kill disease-causing microganisms in dirty source water, is reacting with rotting organic matter like sewage, manure from livestock, dead animals and fallen leaves to form toxic chemicals that are potentially harmful to people.

This unintended side effect of chlorinating water to meet federal drinking water regulations creates a family of chemicals known as **trihalomethanes**. The Environmental Protection Agency lumps them under the euphemism "disinfection byproducts" but we call them what they are: toxic trash.

The EPA regulates four members of the trihalomethane family, the best known of which is **chloroform**, once used as an anesthetic and, in pulp detective stories, to knock out victims. Today, the U.S. government classifies chloroform as a "probable" human carcinogen. California officials consider it a "known" carcinogen. Three other regulated trihalomethanes are bromodichloromethane, bromoform, and dibromochloromethane. Hundreds more types of toxic trash are unregulated.

Scientists suspect that trihalomethanes in drinking water may cause thousands of cases of bladder cancer every year. These chemicals have also been linked to colon and rectal cancer, birth defects, low birth weight and miscarriage (NHDES 2006).

## WHEN DOES WATER TREATMENT CONTAMINATION REACH THE DANGER POINT?

An Environmental Working Group analysis of water quality tests conducted in 2011 and made public last year by 201 large American municipal water systems in 43 states has determined that each of these systems detected thihalomethane contamination. In short, more than 100 million Americans served by these large waterworks were exposed to toxic trash.

Only one of the systems studied by EWG – Davenport, Iowa – exceeded the EPA rule barring more than 80 parts per billion of trihalomethanes in drinking water (see Appendix). This legal limit was set in 1998, based on the potential for trihalomethanes to cause bladder cancer. The 80-parts-per-billion standard was part of a major Clinton administration initiative to improve federal drinking water protections under the federal Safe Drinking Water Act.

Yet the significant toxicity of trihalomethanes and other water contaminants generated by water treatment chemicals, documented by large numbers of scientists around the world, makes a compelling case for lowering the federal legal limit to well below 80 parts per billion. Since 1998, the evidence implicating trihalomethanes in serious disorders has mounted:

In 2011 a French research team, pooling data from studies in France, Finland and Spain, found that men exposed to more than 50 parts per billion of trihalomethanes had significantly increased bladder cancer risks (Costet 2011).

In 2007, a scientific team in Spain associated exposure to trihalomethanes greater than 35 parts per billion with increased bladder cancer risks (Villanueva 2007).

In 2007, researchers from four Taiwanese universities reported that people faced twice the odds of dying from bladder cancer if they drank water with trihalomethane contamination greater than 21 parts per billion. This study was cited in the 2011 National Report on Carcinogens, a Congressionally-mandated report produced by the National Toxicology Program, a federal interagency scientific body (Chang 2007, NTP 2011).

A 2010 study by the National Cancer Institute found that about a quarter of the human population may have a genetic susceptibility that raises its risk of bladder cancer from trihalomethanes (Cantor 2010).

Some 168 of the systems studied by EWG, or 84 percent, reported average annual trihalomethane contamination greater than 21 parts per billion – the level at which Taiwanese researchers detected a heightened risk of bladder cancer. Concentrations greater than 35 parts per billion were found in 107, or 53 percent of these systems. In 2005, the EPA considered lowering the legal limit for trihalomethanes to 40 parts per billion, calculating that this move would prevent nearly 1,300 bladder cancer cases each year and save the U.S. between $2.9 and $7.1 billion (EPA 2005). The agency did not attempt to establish this lower standard as a regulation with the force of law. Instead it made marginal improvements in the way it would measure trihalomethanes for compliance with existing regulations and gave water treatment facilities until 2016 to comply with these modest changes.

## CONTAMINATION SPIKES PRESENT SPECIAL RISKS DURING PREGNANCY

EWG's analysis suggests that many people are likely exposed to far higher concentrations of trihalomethanes than anyone knows. The EPA regulation for these toxic chemicals is based on the system-wide annual average. But in most water systems, trihalomethane contamination fluctuates from month to month, sometimes rising well beyond the 80 parts-per-billion federal cap. Contamination spikes are offset by low readings that keep the systems in legal compliance.

The EPA standard for trihalomethanes is based on preventing bladder cancer, but the agency has noted that that these chemicals may present reproductive and developmental risks as well (EPA 2012a). A spike that lasts three months exposes a pregnant woman and her fetus to excessive trihalomethane for an entire trimester, a critical window of development. Scientific research has shown that such intensive exposure can have serious consequences for the child. Three studies published last year:

Australian scientists found that when women in their third trimester of pregnancy consumed water with 25 parts per billion of chloroform, their newborns were small for their gestational age, meaning that they typically had birth weights in the lowest ten percent of newborns and were at higher risk for a various health problems (Summerhayes 2012).

Canadian researchers found that exposure to more than 100 parts per billion of trihalomethanes during the last trimester of pregnancy was associated with newborns small for their gestational age (Levallois 2012).

Taiwanese researchers linked stillbirth risks to trihalomethane levels as low as 20 parts per billion (Hwang 2012).

Numerous other studies have associated reproductive and developmental problems with trihalomethanes. Among them:

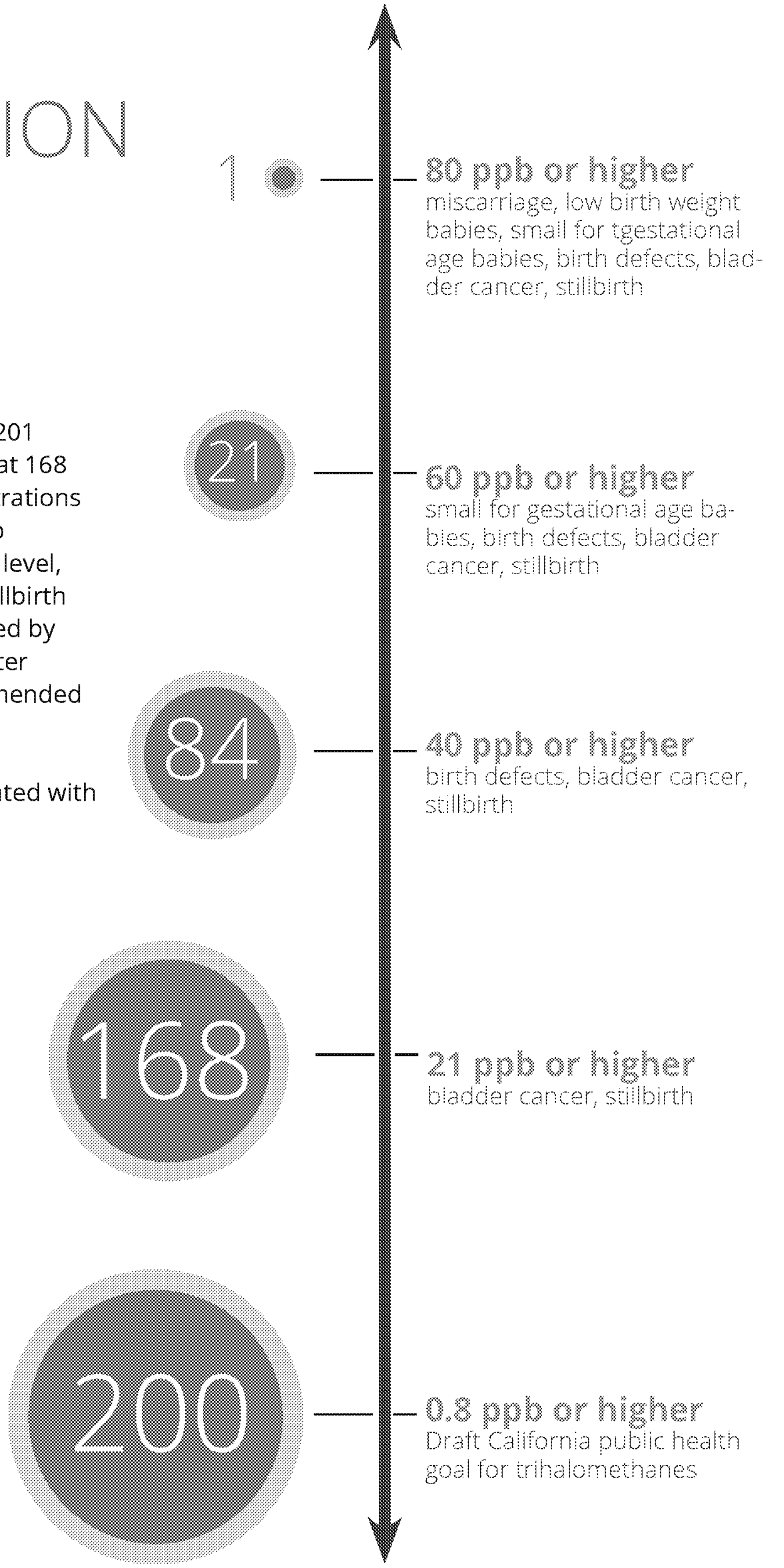
In 2008, scientists from the University of North

# WATER CONTAMINATION BY THE NUMBERS

Water quality tests conducted in 2011 by 201 large water suppliers in 43 states show that 168 of them reported trihalomethane concentrations greater than 21 parts per billion level. Two Taiwanese studies have found that at this level, cancer risk doubles and the chances of stillbirth rise. All but one of the 201 utilities reviewed by EWG reported trihalomethane levels greater than 0.8 parts per billion, the goal recommended by California public health officials.

Shown at right are the health risks associated with each concentration of trihalomethanes.

**NUMBER OF UTILITIES (OUT OF 201)**




References: Bove 2002, Chang 2007, Hoffman 2008, Hwang 2012, Wright 2003

Carolina found that women exposed to more than 80 parts per billion of trihalomethanes during their third trimester of pregnancy faced twice the risk of delivering a child small for gestational age (Hoffman 2008).

British scientists found a link between 60 parts per billion of trihalomethane exposure and stillbirths (Toledano 2005).

In 2003, a team from the Harvard School of Public Health linked exposures to more than 80 parts per billion of trihalomethanes during the second trimester of pregnancy to low birth weight and small-for-gestational-age newborns (Wright 2003).

In 2002 researchers at the federal Agency for Toxic Substances and Disease Registry reviewed the findings of 14 major studies and concluded that there was "moderate evidence" for an association between trihalomethane exposure, small-for-gestational-age newborns, neural tube defects and miscarriage (Bove 2002). The neural tube is the structure in the fetus that develops into the brain and spinal cord.

## TRIHALOMETHANES ARE JUST THE TIP OF THE ICEBERG

Studies have shown that there are more than 600 unwanted chemicals created by the interaction of water treatment disinfectants and pollutants in source water (Barlow 2004, Richardson 1998, 1999a, 1999b, 2003). Most of these water treatment contaminants have not been studied in depth. Among them: haloacetonitriles, haloaldehydes, haloketones, halohydroxyfuranones, haloquinones, aldehydes, haloacetamides, halonitriles, halonitromethanes, nitrosamines, organic N-chloramines, iodoacids, ketones and carboxylic acids (Bond 2011, Bull 2011, EWG 2001, Plewa 2004, Yang 2012). Some of these compounds are suspected carcinogens (Bull 2011). Notably, scientists believe that hundreds more water treatment contaminants are present in drinking water but have not yet been identified (Barlow 2004).

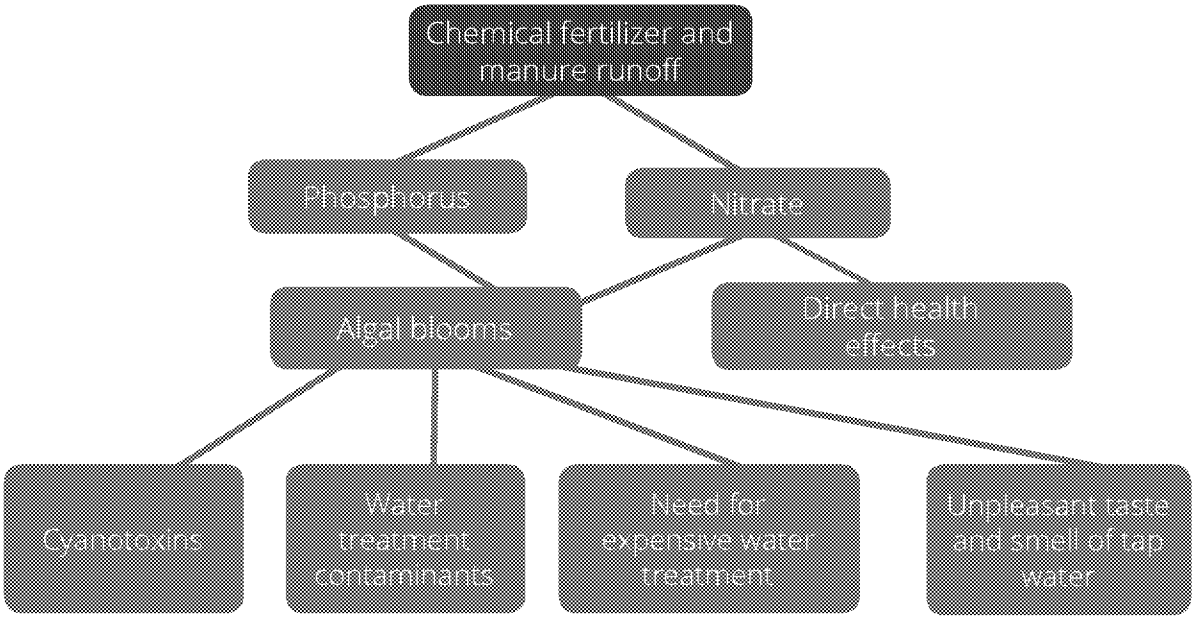
Besides the four regulated trihalomethanes, the EPA regulates five other contaminants in a family of chemicals known as **haloacetic acids** -- monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid (EPA 2012b). The current EPA legal limit for these five chemicals is 60 parts per billion.

While there have been relatively few epidemiological studies on the potential health effects of haloacetic acids, there is evidence suggesting that exposure to these chemicals during the second and third trimesters of pregnancy may be linked to intrauterine growth retardation and low birth weight (Levallois 2012, Hinckley 2005; Porter 2005).

Haloacetic acids have been classified by the EPA as possibly carcinogenic to humans because of evidence of carcinogenicity in animals. According to the EPA, long-term consumption of water that contains haloacetic acid concentrations in excess the legal limit of 60 parts per billion is associated with an increased risk of cancer (EPA 2002). A technical bulletin released by the Oregon Department of Human Services in 2004 warned that long-term exposure to haloacetic acids at or above 60 parts per billion may cause injury to the brain, nerves, liver, kidneys, eyes and reproductive systems.

Some studies point to concerns with specific haloacetic acids. Dibromoacetic acid has been shown to disturb the balance of the intestinal tract and to cause disease, especially in people with weakened immune systems (Rusin 1997). This particular haloacetic acid compound is toxic to the sperm of adult rats at concentrations as low as 10 parts per billion. At high doses, it has caused a range of neurological problems in test animals, including awkward gait, tremors and immovable hind limbs (Linder 1995). Two members of the haloacetic acid family -- dichloroacetic acid and trichloroacetic acid -- have been shown to cause severe skin and eye irritations in humans (NTP 2005).

# WATER POLLUTION CASCADE FROM AGRICULTURAL RUNOFF




## A CHLORINE SUBSTITUTE THAT DOESN'T SOLVE THE PROBLEM – AND MAY MAKE IT WORSE

In recent years, many water utilities have tried to reduce contamination caused by water treatment by switching from free chlorine to chloramines, compounds made from chlorine and ammonia gases.

Chloramines are more stable than chlorine and do not produce as many trihalomethanes and haloacetic acids. The EPA has reported that when Washington Aqueduct, a U.S. Corps of Engineers facility that treats drinking water for Washington D.C., switched to chloramines, the estimated average of the regulated water treatment contaminants in theses two families dropped by 47 percent (EPA 2006).

Yet switching to chloramines has not solved the problem but rather moved the problem – and may have complicated it.

Chloramines are toxic to kidney dialysis patients and extremely toxic to fish (EPA 2012b).

A nationwide study on water treatment contaminants conducted by the EPA reported that chloraminated drinking water had the highest levels of an unregulated chemical family known as **iodoacids** (EPA 2002). Some researchers consider iodoacids to be potentially the most toxic group of water treatment contaminants found to date, but there is still relatively little research on them (Barlow 2004, Plewa 2004).

Other dangerous compounds formed by chloramine are nitrosamines. In 2010, then-EPA Administrator Lisa Jackson launched a new "drinking water strategy." During these deliberations, the agency is addressing, among other things, nitrosamine contamination. Nitrosamines, which are currently unregulated, form when water is disinfected with chloramine. The U.S. government says some chemicals in the nitrosamine family are "reasonably anticipated" to be human carcinogens.

In a 2011 report called "The Chlorine Dilemma," David Sedlak, a professor of civil and environmental engineering at the University of California-Berkeley, detailed the "dark side" of water treatment and the new and unanticipated hazards of water treatment plants' shift from chlorine to chloramine. "Nitrosamines are the compounds that people warned you about when they told you you shouldn't be eating those nitrite-cured hot dogs," Sedlak told National Public Radio in 2011. "They're about a thousand times more carcinogenic than the disinfection byproducts that we'd been worried about with regular old chlorine."

The bottom line is that switching to chloramination may have achieved the desired effect of reducing trihalomethane and haloacetic acid levels, but it may have inadvertently exposed the population to additional unregulated byproducts that are more harmful in the long run.

Chloramines present other potential problems. Utilities observed that chloramines were not as effective at disinfection as free chlorine, so, according to the EPA, many treatment plants began to alternate between chloramines and chlorine to "dislodge biofilms and sediment in water mains" (EPA 2007). When chlorine was reintroduced to a system for a month-long "chlorine flush" (EWG 2007), the result was "chlorine burn," which removed sludge and sediment from pipes but also temporarily raised the level of chlorine-generated contaminants. Customers of utilities that used both types of chemicals were exposed to varying amounts of multiple water treatment contaminants.

There were more severe and long-lasting complications. In 2000, the Washington Aqueduct switched to chloramine without realizing that chlorine prevented corrosion of old lead pipes but chloramine did not (Brown 2010). The switch caused D.C.'s old lead pipes to discharge quantities of lead into the city's drinking water, triggering a public health crisis when the problem was detected in 2004. The belated discovery of high lead levels triggered warnings, broad distribution of water filters, firings, Congressional hearings and extensive replacement of lead water lines.

In a study published in January 2009 in the journal of Environmental Science and Technology, scientists Marc Edwards and Simoni Triantafyllidou of Virginia Tech and Dana Best of the Children's National Medical Center in Washington wrote that during the D.C. lead crisis, the number of babies and toddlers with elevated lead levels in their blood increased by more than four times, compared to the pre-2001 period (Edwards 2009). The authors warned that many of the youngest could suffer irreversible IQ loss or other developmental difficulties.

## CLEANING UP SOURCE WATER

Cleaner source water is critical to breaking this cycle. By failing to protect source water, Congress, EPA and polluters leave Americans with no choice but to treat it with chemical disinfectants and then consume the residual chemicals generated by the treatment process.

For most utilities with chronically high readings of treatment pollutants, cleaning up source water will require aggressive action to reduce agricultural pollution, runoff from suburban sprawl and upstream sewage discharges.

Superstorm Sandy exerted unprecedented pressure on sources of drinking water along the East Coast. In the storm's wake, tens of millions of gallons of sewage washed into waterways and the Chesapeake Bay. The Federal Emergency Management Agency advised people in areas slammed by the storm to boil tap water. New York Gov. Andrew Cuomo estimated that the costs of repairing damaged sewage pumping stations and treatment plants in his state alone could surpass $1.1 billion. The fragile Chesapeake, already the site of a long-running environmental cleanup, was deluged with sewage from water treatment systems swamped by pounding rains. In Virginia, most of the lower Chesapeake Bay suffered widespread sewage contamination and was closed to shell-fishing for a period.

These are serious issues that must be addressed. The smart choice will be to make infrastructure improvements that help protect source water. It doesn't take a perfect storm for sewage to pollute the Potomac River. The Washington D.C. area's aging sewage pipes do that regularly. To remedy the problem, Washington authorities have embarked on a complex, long-term sewage control plan called the Clean Rivers project, estimated to cost $2.6 billion and wind up in 2025.

Other urban areas are long overdue for upgrades to their sewage and storm water management systems. In 2002, the EPA estimated that modernizing wastewater control systems nationwide to meet rising demand would require capital investment of $390 billion over the next 20 years. In 2009, the American Society of Civil Engineers gave the nation a D-minus for inattention to its wastewater systems. "Clean and safe water is no less a national priority than are national defense, an adequate system of interstate highways, and a safe and efficient aviation system," the organization said. "Many other highly important infrastructure programs enjoy sustainable, long-term sources of federal backing, often through the use of dedicated trust funds; under current policy, water and wastewater infrastructure do not."

Treating fouled water with chemicals can be more expensive than reducing pollution before it gets to the treatment plant. Research has shown that the long-term economic benefits of keeping source water clean often far outweigh the costs. The EPA has found that every dollar spent to protect source water reduced water treatment costs by an average of $27 (CBF 2012). Philadelphia officials have estimated that every dollar they invest in green infrastructure to reduce storm water flows will create more than double the economic benefits (PWD 2009).

In much of the country, farming is a major

## Recommendations for consumers

Anyone drinking tap water should use some form of carbon filtration designed to reduce exposures to trihalomethanes, haloacetic acids and other water treatment contaminants.

Carbon filtration systems come in various forms, including pitchers, faucet-mounted attachments and larger systems installed on or under countertops. Prices vary. They may be deceiving, because different systems require filter replacement periodically.

EWG research shows that pitcher and faucet-mounted systems are typically the most economical, costing about $100 a year. Countertop and under-counter systems are more expensive to install, with yearly maintenance costs roughly equal to pitcher and faucet-mounted systems.

The prices for all of these systems pale in comparison to the expense of purchasing bottled water for a family of four, which EWG estimates to range between $950 and $1,800 a year.

Before purchasing any filtration system, it is important to research them. Not all activated carbon systems remove water treatment contaminants. Click here to see a list of some filters that reduce the concentrations of at least one of these chemical families. (http://www.ewg.org/report/ewgs-water-filter-buying-guide)

Consumers who are serious about avoiding water treatment contaminants should consider installing a whole-house filtration system. Numerous studies have shown that showering and bathing are important routes of exposure for trihalomethanes and may actually contribute more to total exposure than drinking water (OEHHA 2004, Xu and Weisel 2003).

It is critical, however, that consumers research their choices carefully. Many whole-house systems do not remove water treatment contaminants. In fact, when EWG was assembling the latest edition of its filter guide, we could not find a single whole-house system that was certified by the state of California or NSF International, an independent, non-profit certification body, to reduce trihalomethanes. Those that do may cost several hundred or even thousands of dollars and incur yearly maintenance costs of hundreds of dollars more.

Whichever system you choose, remember to change the filter according to the manufacturer's guidelines, or it will become clogged and cease to function effectively. (http://www.ewg.org/report/water-filter-maintenance) source of organic pollution in drinking water and a contributor to water treatment contamination. Farming communities need common sense standards to reduce soil erosion and polluted runoff from agricultural operations. Farm operators and landowners should be expected to implement a basic standard of care involving simple and often conventional practices that improve soil and water quality. These should be a condition of eligibility for receiving the generous federal benefits accorded agricultural operations. States should take action to enact narrowly-targeted standards that restrict farming practices that inflict a disproportionally large amount of natural resource damage.

About 1 billion tons of topsoil erode from American cropland each year, much of it deposited in streams and rivers. Soil mixed with manure washed from pasture and rangelands contains even more fecal matter and other organic substances (USDA 2001, EWG 2012a).

Studies by the U.S. Geological Survey have found that fertilizer used in agriculture accounted for 17 percent of total phosphorus in major U.S. river basins (CSP 2007). Most phosphorus from fertilizer is absorbed into soil in fields and is carried to streams and rivers during soil erosion. USGS studies show that three-quarters of all American streams and rivers are polluted with enough phosphorus to support uncontrolled algae growth (USGS 1999, Cooke 1989). In bodies of water, algae blooms die, decompose and, like other organic matter, give off fulvic and humic acids that react with chlorine during treatment to form trihalomethanes,

With the exception of large animal feeding operations, farm businesses are exempt from the pollution control requirements of the federal Clean Water Act. Few states have authority to compel farms to adopt practices that would reduce agricultural pollution reaching rivers, lakes and bays.

For example, according to the Iowa Department of Natural Resources, 92 percent of the nitrogen and 80 percent of the phosphorus – the two pollutants most responsible for the poor condition of the waterways that it monitors – come mainly from agricultural runoff. Only 8 percent of the nitrogen and 20 percent of the phosphorus come from "municipal and industrial discharges." Yet Iowa's water quality regulation almost exclusively targets municipal and industrial discharges. Agricultural runoff remains largely unregulated (EWG 2012b).

The federal farm bill, reauthorized every five years, sets national policy for source water protection. The current debate over renewing the farm bill can be viewed as a referendum on the nation's commitment to protect drinking water supplies at the source. This legislation affects the nation's waters in two opposing ways. On one hand it authorizes subsidies that encourage all-out production of feed grains and oilseeds, spurring increased pollution and habitat destruction. On the other, it offers incentives to farmers who protect the environment.

In exchange for federal subsidies, farmers since 1985 have agreed to adopt soil conservation measures to minimize erosion and protect wetlands. As a result of this "conservation compact" between farmers and taxpayers, soil erosion on highly erodible land was reduced by 40 percent in recent decades. The nation met the long-sought goal of no net loss of wetlands.

Now, however, some lobbyists and legislators want to end this compact, opposing proposals to restore the link between "conservation compliance" and crop insurance subsidies, which are the government's chief form of income support for farm businesses. To finance those subsidies, many of the same lobbyists and legislators have proposed cutting programs managed by the U.S. Department of Agriculture to help farmers pay for conservation measures. These cuts would reverse a gradual trend in recent decades that has seen annual spending on conservation increase from $2 billion to more than $4 billion, with greater incentives for farmers who take steps to reduce water pollution (EWG 2012a).

If conservation funding is slashed, the U.S. will give up important gains that have constrained agricultural pollution. The problem of water treatment contaminants is likely to become more pronounced.

## THE TROUBLE WITH EPA

The EPA's rules for water treatment contaminants date back to 1974, when scientists discovered that chlorine was reacting with dissolved pollution in the water supply to create more contaminants. Five years later, the EPA set the nation's first standards for trihalomethanes at 100 parts per billion, calculated as the running annual average of total concentration of the chemicals.

In 1998, the Clinton EPA lowered the trihalomethane cap to a running annual average of 80 parts per billion and set a new legal limit for haloacetic acids at a running annual average of 60 parts per billion.

But the agency's regulatory scheme succeeded in conveying a false sense of security to the public.

As noted earlier, the EPA regulates just nine pollutants generated by chlorine or chloramine--four trihalomethanes and five haloacetic acids (EPA 2012a). These nine regulated chemicals represent less than 2 percent of the more than 600 unwanted chemicals created by the interaction of water treatment disinfectants and pollutants in source water (Barlow 2004).

The legal limits for the nine regulated chemicals are not what either the agency or many independent scientists believe is truly safe. Rather, the regulations represent political compromises that take into account the costs and feasibility of treatment.

In 2010, California's Office of Environmental Health Hazard Assessment proposed a "public health goal" for trihalomethanes of 0.8 parts per billion. A "goal" is not a binding legal limit, but setting a goal is the first step in the process that establishes such a limit. California regulators estimated that if the goal of 0.8 parts per billion were attained, bladder cancer risks would be reduced to no more than 1 in a million (OEHHA 2010). The state is still in the process of publishing its final goal. Still, the 2010 proposal represents what California's public health and environmental experts believe should be done to protect the public from carcinogenic trihalomethanes. It is significant that that this proposed goal is one-hundredth of the EPA cap.

Yet another problem is of the EPA's own making. The agency established an unusual monitoring method that all but guaranteed that many Americans would be overexposed periodically to spikes in water treatment contamination. For most toxic chemicals in drinking water, the agency set a simple limit on the maximum level of the contaminant that could be measured at any time. But for water treatment contaminants, the agency permitted utilities to average the pollution throughout their systems and over the previous four quarters. This method made it legal for utilities to distribute excessively contaminated water from chronically problematic sections and use readings from other sections that were below average to remain in compliance with federal law and regulations.

This flaw is not theoretical. EWG's analysis of 201 utilities' water quality reports for 2012, known as "consumer confidence reports," uncovered several utilities in which annual trihalomethane and/or haloaceticacid levels for some sampling locations spiked to between 2 and 8 times higher than other sampling locations within the same systems. The entire systems escaped penalties because their water averaged out with a passing grade from EPA. But at certain times and in certain places, the water was excessively tainted, sometimes severely so. Pregnant women and their unborn children could be affected by these spikes.

In 2005, responding to critics of this complicated and flawed method, the EPA proposed new rules to go into effect between 2012 and 2016, depending on the size of the water system. These would require water utilities to find spots within their systems that had markedly high concentrations of water treatment contaminants and designate these locations as monitoring sites for compliance with federal drinking water standards. The EPA asserted that these new rules would prevent an estimated 280 cases of bladder cancer each year.

But EPA's plan represented only a partial solution. It retained the system-wide averaging method and would not solve the problem of recurrent contaminant spikes at particular locations.

To examine this issue further. EWG created a case study, analyzing detailed water treatment contaminant data for all 936 water utilities in Florida.

We found that fully nine percent of all the tests exceeded the EPA maximum for trihalomethanes. The most contaminated water measured an astonishing 595 parts per billion. In four percent of the tests, haloacetic acids exceeded the EPA maximum, with some levels as high as 260 parts per billion. Spikes typically appeared in early spring and late summer.

## POLICY RECOMMENDATIONS

If source water were less polluted as it flowed into a water utility's intake pipes, less disinfection with chlorine and chloramines would be needed, and these treatment chemicals would produce less contamination. But government policies do little to advance this goal.

Instead, taxpayers pour billions of dollars into federal programs like farm subsidy payments that exacerbate pollution and then pile on additional billions of dollars for water treatment facilities. Not enough federal money and effort are being devoted to finding more effective and efficient measures to protect rivers and streams from pollution in the first place.

Until such measures are in place and contaminant levels are dramatically reduced, EWG makes these recommendations for national policy:

- The EPA should reevaluate its legal limits for water treatment contaminants in light of the latest scientific research indicating that lower limits are well justified to protect human health.
- Congress should reform farm policies to provide more funds to programs designed to keep agricultural pollutants such as manure, fertilizer, pesticides and soil out of tap water.
- Congress should renew the "conservation compliance" provisions of the 1985 farm bill by tying wetland and soil protection requirements to crop insurance programs, by requiring farm businesses that receive subsidies to update their conservation plans and by strengthening the government's enforcement tools.
- Congress should strengthen and adequately fund conservation programs that reward farmers who take steps to protect sources of drinking water. Congress should expand "collaborative conservation" tools that award funds to groups of farmers who work together to protect drinking water sources.
- The USDA and other federal agencies involved in federal agriculture policy should place greater emphasis on restoring buffers and wetlands that filter runoff contaminated with farm pollutants.
- The federal government should fund more research on the identity of and toxicological profiles for the hundreds of water treatment contaminants in drinking water.
- The EPA must reevaluate the way it measures water treatment contaminants so that consumers cannot be legally exposed to spikes of toxic chemicals.
- Congress must allocate significant money to help repair and upgrade the nation's water infrastructure.
- Source water protection programs should be significantly expanded, including efforts to prevent or reduce pollution of source waters and to conserve land in buffer zones around public water supplies. Financial support for these projects is crucial.

## APPENDIX

# WATER TREATMENT CONTAMINANTS IN 201 LARGE WATER UTILITIES

Running annual average levels of trihalomethanes and haloacetic acids for the year 2011 as reported in the 2012 Consumer Confidence Reports of 201 large U.S. water utilities.

| State | Water Supplier | Locations Served (in whole or part) | Total Trihalomethane Running Annual Average (in parts per billion) | Haloacetic Acids Running Annual Average (in parts per billion) |
|---|---|---|---|---|
| AK | Anchorage Water & Wastewater Utility | Anchorage | 4.9 | 5.0 |
| AL | Huntsville Utilities Water Department | Huntsville | 34.4 | 23.9 |
| AL | Montgomery Water Works & Sanitary Sewer Board | Montgomery | 22.0 | 15.0 |
| AR | Beaver Water District | Fayetteville, Springdale, Rogers, and Bentonville | 63.6 | 37.3 |
| AR | Central Arkansas Water | Little Rock | 53.0 | 25.0 |
| AZ | City of Chandler Municipal Utilities Department | Chandler | 46.2 | 16.6 |
| AZ | City of Glendale Water Services | Glendale | 50.0 | 14.7 |
| AZ | City of Mesa Water Resources Department | Mesa | 59.1 | 17.7 |
| AZ | City of Phoenix Water Services Department | Phoenix | 58.0 | 22.0 |
| AZ | City of Scottsdale Water Resources | Scottsdale | 54.0 | 17.5 |
| AZ | City of Tempe Water Utilities Division | Tempe | 62.0 | 24.0 |
| AZ | Town of Gilbert Public Works | Gilbert | 43.9 | 16.1 |
| CA | Alameda County Water District | Fremont, Newark, and Union City | 26.0 | 17.0 |
| CA | Anaheim Public Utilities | Anaheim | 33.0 | 14.0 |
| CA | Azusa Light and Water | Azusa | 23.6 | 16.8 |
| CA | California Water Service Company-Bakersfield | Bakersfield | 41.0 | 39.0 |
| CA | Castaic Lake Water Agency | Santa Clarita, Canyon Country and Newhall | 25.6 | 8.0 |
| CA | Chino Hills Water and Sewer | Chino Hills | 32.5 | 3.6 |
| CA | City of Antioch | Antioch | 47.7 | 5.4 |
| CA | City of Fresno Water Division | Fresno | 0.8 | 2.5 |
| CA | City of Glendale Water and Power | Glendale | 38.4 | 11.0 |
| CA | City of Huntington Beach | Huntington Beach | 31.0 | 18.0 |
| CA | City of Modesto | Modesto | 28.7 | 18.8 |

| | | | | |
|---|---|---|---|---|
| CA | City of Oceanside | Oceanside | 37.0 | 11.0 |
| CA | City of Orange | Orange | 24.0 | 13.0 |
| CA | City of Riverside Public Utilities | Riverside | 4.1 | not listed |
| CA | City of Sacramento Department of Utilities | Sacramento | 44.0 | 23.0 |
| CA | City of Santa Ana Public Works | Santa Ana | 52.0 | 23.0 |
| CA | City of Torrance Water Department | Torrance | 41.2 | 13.9 |
| CA | Contra Costa Water District | Contra Costa County | 47.7 | 5.4 |
| CA | Cucamonga Valley Water District | Rancho Cucamonga, Upland, Ontario, and Fontana | 46.0 | 18.0 |
| CA | East Bay Municipal Utility District | Alameda and Contra Costa Counties | 44.0 | 25.0 |
| CA | East Orange County Water District-Wz | Orange | 48.0 | 29.0 |
| CA | Eastern Municipal Water District | Riverside County | 59.0 | 24.0 |
| CA | Helix Water District | San Diego County | 48.1 | 11.8 |
| CA | Irvine Ranch Water District | Irvine | 39.0 | 25.0 |
| CA | Joint Regional Water Supply System | Orange County | 48.0 | 16.0 |
| CA | Los Angeles Department of Water and Power | Los Angeles | 45.0 | 28.0 |
| CA | Marin Municipal Water District | Marin County | 28.0 | 16.0 |
| CA | Metropolitan Water District of Southern California | Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties | 43.0 | 18.0 |
| CA | San Diego Water Department | San Diego | 63.8 | 15.1 |
| CA | San Francisco Public Utilities Commission | San Francisco, San Mateo, Alameda and Santa Clara counties | 42.0 | 34.0 |
| CA | San Jose Water Company | San Jose | 32.7 | 15.7 |
| CA | Ventura Water Department | Ventura | 30.0 | 25.0 |
| CO | Aurora Water | Aurora | 14.2 | 16.4 |
| CO | City of Fort Collins Utilities | Fort Collins | 32.1 | 19.0 |
| CO | Colorado Springs Utilities | Colorado Springs | 38.0 | 45.0 |
| CO | Denver Water | Denver | 29.0 | 18.0 |
| CT | Aquarion Water Company | Bridgeport | 38.0 | 33.0 |
| CT | Metropolitan District Commission | Hartford | 68.7 | 28.4 |
| CT | South Central Connecticut Regional Water Authority | New Haven | 29.0 | 22.0 |
| CT | Waterbury Bureau of Water | Waterbury | 45.0 | 43.0 |
| DC | D.C. Water and Sewer Authority | Washington, D.C. | 41.0 | 27.0 |
| DE | Artesian Water Company | Newark | 16.6 | 13.4 |
| FL | Charlotte County Utilities | Charlotte, DeSoto, and Sarasota counties and the city of North Port | 33.9 | 27.6 |
| FL | City of Cocoa Claude H. Dyal Water Treatment Plant | Cocoa | 38.3 | 40.3 |



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|---|---|---|---|---|
| FL | City of Hialeah - Department of Water and Sewers | Hialeah | 30.0 | 28.0 |
| FL | City of Lakeland, Department of Water Utilities | Lakeland | 36.7 | 17.0 |
| FL | City of North Miami Beach Public Services Department | North Miami Beach | 13.8 | 6.9 |
| FL | City of Port St Lucie Utility Systems Department | Port St Lucie | 26.4 | 14.4 |
| FL | Collier County Water Department | Naples | 35.0 | 14.2 |
| FL | Emerald Coast Utilities Authority | Pensacola | 3.8 | 1.3 |
| FL | Hillsborough County Water Resource Services-South Hillsborough | Lithia | 24.0 | 7.7 |
| FL | JEA | Jacksonville | 37.9 | 16.8 |
| FL | Lee County Utilities | Fort Myers | 8.7 | 9.0 |
| FL | Manatee County Utilities Department | Bradenton | 40.7 | 30.6 |
| FL | Melbourne Public Works & Utilities Department | Melbourne | 44.6 | 11.8 |
| FL | Miami-Dade Water and Sewer Department | Miami | 30.0 | 28.0 |
| FL | Orange County Utilities Deparment | Orange County | 61.8 | 36.3 |
| FL | Orlando Utilities Commission | Orlando | 49.0 | 18.0 |
| FL | Palm Bay Utilities | Palm Bay | 22.8 | 7.1 |
| FL | Palm Beach County Water Utilities Department | Palm Beach County | 27.7 | 22.3 |
| FL | Pasco County Utilities-Pasco County Regional Water System | Pasco County | 17.7 | 9.4 |
| FL | Pinellas County Utilities | Clearwater | 36.5 | 21.4 |
| FL | Tampa Water Department | Tampa | 35.1 | 10.8 |
| GA | Atlanta Department of Watershed Management | Atlanta | 44.0 | 40.0 |
| GA | Cherokee County Water and Sewerage Authority | Cherokee County | 55.9 | 53.7 |
| GA | Clayton County Water Authority | Clayton County | 48.4 | 23.9 |
| GA | Cobb County Water System | Cobb County and the cities of Acworth and Kennesaw | 37.0 | 21.0 |
| GA | Columbus Water Works | Columbus | 30.3 | 18.5 |
| GA | Dekalb County Watershed Management | DeKalb County | 22.0 | 7.0 |
| GA | Douglasville-Douglas County Water and Sewer Authority | Douglasville | 52.4 | 31.0 |
| GA | Gwinnett County Department of Water Resources | Buford | 18.6 | 12.0 |
| IA | Cedar Rapids Water Department | Cedar Rapids | 1.4 | 0.4 |
| IA | Des Moines Water Works | Des Moines | 36.0 | 7.0 |

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|---|---|---|---|---|
| IA | Iowa American Water Company-Davenport | Davenport | 92.0 | 27.0 |
| ID | United Water Idaho Inc | Boise | 17.6 | 13.0 |
| IL | Chicago Department of Water Management | Chicago | 19.6 | 10.5 |
| IL | IL-American Water East St Louis | East St Louis | 18.5 | 22.1 |
| IL | IL-American Water Peoria | Peoria | 32.5 | 11.5 |
| IN | Citizens Water | Indianapolis | 46.0 | 42.0 |
| IN | Evansville Water and Sewer Utilities | Evansville | 37.0 | 22.7 |
| IN | Fort Wayne City Utilities-Three Rivers Filtration Plant | Fort Wayne | 47.1 | 45.1 |
| IN | Indiana American Water-Northwest | Gary | 25.5 | 13.5 |
| KS | Water District 1 of Johnson County | Johnson County | 24.0 | 22.0 |
| KS | Wichita Water Utilities | Wichita | 25.0 | 11.0 |
| KY | Kentucky-American Water | Lexington | 47.0 | 31.0 |
| KY | Louisville Water Company | Louisville | 26.6 | 16.7 |
| KY | Northern Kentucky Water District | Fort Thomas | 72.0 | 58.0 |
| LA | Jefferson Parish | Jefferson Parish | 62.0 | 33.0 |
| LA | Sewerage and Water Board of New Orleans | New Orleans | 36.0 | 21.0 |
| LA | Shreveport Department of Water and Sewerage | Shreveport | 23.4 | 18.5 |
| MA | Lowell Regional Water Utility | Lowell | 49.2 | 14.9 |
| MA | Massachusetts Water Resources Authority | Boston | 8.7 | 8.7 |
| MA | Springfield Water and Sewer Commission | Springfield | 63.0 | 33.0 |
| MA | Worcester DPW, Water Supply Division | Worcester | 48.0 | 46.0 |
| MD | Baltimore City Department of Public Works | Baltimore | 52.0 | 54.0 |
| MD | Washington Suburban Sanitary Commission | Potomac | 41.9 | 34.7 |
| MI | Detroit Water and Sewerage Department | Detroit | 33.1 | 17.8 |
| MI | Grand Rapids | Grand Rapids | 37.6 | 26.0 |
| MI | Lansing Board of Water and Light | Lansing | 4.6 | 3.0 |
| MN | City of Minneaplis Water Department | Minneapolis | 32.1 | 26.3 |
| MN | Saint Paul Regional Water Services | Saint Paul | 44.6 | 27.1 |
| MO | City of St Louis Water Division | St Louis | 19.5 | 17.2 |
| MO | City Utilities | Springfield | 17.8 | 15.2 |

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|---|---|---|---|---|
| MO | Kansas City Water Services Department | Kansas City | 8.4 | 17.1 |
| MO | Missouri American Water-St Louis/St Charles County | St Louis | 31.1 | 20.1 |
| MT | City of Billings | Billings | 39.5 | 35.5 |
| NC | Cape Fear Public Utility Authority | Wilmington | 61.0 | 13.1 |
| NC | City of Asheville | Asheville | 27.4 | 22.6 |
| NC | City of Durham | Durham | 44.6 | 28.0 |
| NC | City of Greensboro Department of Water Resources | Greensboro | 60.3 | 46.1 |
| NC | City of Raleigh Public Utilities Department | Raleigh | 33.7 | 15.2 |
| NC | Onslow Water and Sewer Authority | Jacksonville | 53.0 | 19.0 |
| NC | Winston-Salem/Forsyth County Utility Commission | Clemmons | 46.1 | 32.4 |
| NE | Metropolitan Utilities District | Omaha | 50.0 | 22.3 |
| NJ | American Water Company-Coastal North | Shrewsbury | 63.5 | 51.3 |
| NJ | American Water Company-Ocean City | Ocean City | 19.0 | 6.0 |
| NJ | American Water Company-Short Hills | Short Hills | 3.0 | 1.0 |
| NJ | Middlesex Water Company | Woodbridge Township | 45.0 | 28.6 |
| NJ | New Jersey American Water-Delaware | Palmyra | 37.0 | 10.0 |
| NJ | New Jersey American Water-Elizabeth | Elizabeth | 60.0 | 31.0 |
| NJ | New Jersey District Water Supply Commission-Wanaque North | Wanaque | 62.0 | 24.0 |
| NJ | Passaic Valley Water Commission | Totowa Borough | 27.0 | 44.0 |
| NJ | United Water Bergen County | Bergen County | 32.3 | 13.7 |
| NM | Albuquerque Bernalillo County Water Utility Authority | Albuquerque | 19.0 | 7.0 |
| NV | City of Henderson | Henderson | 61.0 | 21.0 |
| NV | City of North Las Vegas Utilities Department | North Las Vegas | 56.0 | 24.0 |
| NV | Las Vegas Valley Water District | Las Vegas | 62.0 | 27.0 |
| NV | Truckee Meadows Water Authority | Reno, Sparks and Washoe County | 30.9 | 30.4 |
| NY | Buffalo Water Authority | Portions of the City of Buffalo | 29.9 | 16.0 |
| NY | City of Syracuse Water Department | Syracuse | 46.0 | 22.0 |
| NY | Erie County Water Authority | Portions of the City of Buffalo | 39.0 | 17.0 |
| NY | Mohawk Valley Water Authority | Utica | 52.0 | 26.0 |
| NY | Monroe County Water Authority | Greece | 39.0 | 19.0 |

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|---|---|---|---|---|
| NY | New York City Department of Environmental Protection | New York | 57.0 | 51.0 |
| NY | Onondaga County Water Authority (OCWA) | Syracuse | 64.6 | 37.9 |
| NY | Rochester City | Rochester | 46.0 | 32.0 |
| NY | Suffolk County Water Authority | Portions of Suffolk County | 7.4 | 0.9 |
| NY | United Water New York | Clarkstown | 23.9 | 13.9 |
| NY | Yonkers City | Yonkers | 40.0 | 47.1 |
| OH | Akron Public Utilities Bureau | Akron | 55.3 | 48.4 |
| OH | City of Columbus Department of Public Utilities | Columbus | 54.4 | 37.1 |
| OH | City of Toledo Division of Water | Toledo | 48.2 | 16.2 |
| OH | Cleveland Division of Water | Cleveland | 33.7 | 24.1 |
| OH | Greater Cincinnati Water Works | Cincinnati | 46.6 | 11.8 |
| OK | City of Tulsa Water Supply System | Tulsa | 52.0 | 16.0 |
| OR | Eugene Water and Electric Board | Eugene | 22.6 | 23.2 |
| OR | Portland Water Bureau | Portland | 22.0 | 26.0 |
| PA | Allentown City Bureau of Water | Allentown | 29.0 | 14.4 |
| PA | Aqua Pennsylvania Inc Main Division | Bucks, Montgomery, Delaware, Philadelphia, and Chester counties | 33.0 | 24.0 |
| PA | City of Bethlehem | Bethlehem | 34.7 | 31.7 |
| PA | Pennsylvania American Water Company-Lake Scranton | Area of Scranton | 34.0 | 18.0 |
| PA | Pennsylvania American Water Company-Pittsburgh | Pittsburgh | 60.1 | 14.9 |
| PA | Philadelphia Water Department | Philadelphia | 42.0 | 24.0 |
| PA | Pittsburgh Water and Sewer Authority | Pittsburgh City | 66.0 | 17.0 |
| PA | West View Water Authority | West View Borough | 48.0 | 16.4 |
| RI | Providence Water | Providence | 75.8 | 20.9 |
| SC | Charleston Water System | Charleston | 26.5 | 23.3 |
| SC | City of Columbia | Columbia | 29.0 | 24.0 |
| SC | Greenville Water System | Greenville | 14.0 | 11.9 |
| SD | Sioux Falls | Sioux Falls | 34.7 | 10.7 |
| TN | Clarksville Water Department | Clarksville | 42.0 | 30.0 |
| TN | Knoxville Utilities Board | Knoxville | 64.0 | 29.0 |
| TN | Nashville Water Department #1 | Nashville | 38.4 | 31.9 |
| TX | Arlington Water Utilities | Arlington | 13.9 | 5.8 |
| TX | Austin Water Utility | Austin | 34.6 | 13.7 |
| TX | City of Carrollton | Carrollton | 13.5 | 13.0 |
| TX | City of Garland | Garland | 36.2 | 16.5 |
| TX | City of Houston Public Works | Houston | 17.0 | 9.0 |
| TX | City of Irving | Irving | 12.5 | 16.7 |
| TX | City of Plano Utilities Operation Department | Plano | 36.5 | 16.2 |

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|---|---|---|---|---|
| TX | Corpus Christi Water Department | Corpus Christi | 58.4 | 18.7 |
| TX | Dallas Water Utilities | Dallas | 10.8 | 12.0 |
| TX | El Paso Public Utilities Board Water Service | El Paso | 29.3 | 5.6 |
| TX | Lubbock Public Water System | Lubbock | 15.0 | 4.1 |
| UT | Weber Basin Water Conservancy District | Davis and Weber counties | 27.6 | 25.2 |
| VA | Arlington County | Arlington | 49.0 | 35.0 |
| VA | Chesterfield County Central Water System | Chesterfield | 26.8 | 18.1 |
| VA | City of Richmond | Richmond | 24.0 | 27.0 |
| VA | City of Virginia Beach Water Department | Virginia Beach | 43.0 | 27.0 |
| VA | Fairfax County Water Authority | Fairfax, Alexandria, Prince William, and Loudoun counties | 27.0 | 15.0 |
| VA | Henrico County Public Utilities | Henrico County | 25.0 | 30.0 |
| VA | Newport News Water Works | Newport News | 19.0 | 17.0 |
| VA | Norfolk Department of Utilities | Norfolk | 47.0 | 32.0 |
| VA | Western Virginia Water Authority | Roanoke | 32.0 | 31.0 |
| WA | City of Tacoma Water Division | Tacoma | 29.7 | 38.7 |
| WA | Seattle Public Utilities | Seattle | 38.0 | 27.0 |
| WI | Madison Water Utility | Madison | 4.3 | 0.4 |
| WI | Milwaukee Water Works | Milwaukee | 10.0 | 2.4 |
| WV | West Virginia American Water-Elk River Regional System | Kanawha, Boone, Putnam, Lincoln, Logan and Cabell counties | 49.0 | 21.0 |

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**DRAFT Agenda, R5/MDH NCWS meeting**

**May 15, 2013, 8-9:30 am**

I. **Introductions**

II. **Review of outstanding items from April 15 meeting (see red typeface) for further discussion, attached.**

III. **Enforcement Verification draft report big picture themes & request for comments**

IV. **Timeframe for next meeting**

## Attachment A. Notes and Status of Action Items, R5/MDH NCWS meeting

## April 15, 2013, 1-3 pm

## 15th floor, Room 15B

I. Introductions: Jerry Smith, Tom Poy, Rita Bair, Heather Shoven, Miguel DelToral, Tom Murphy, Janet Kuefler, Michele Palmer

II. GWR/RTCR sampling—Miguel and Jerry discussed potential difficulties with existing GWR and RTCR monitoring schedules.

**Action Items:** We agreed to have ongoing discussions on this and the accompanying primacy application, and also Janet, Ron Kovach, and Jerry Smith will discuss with Dan Hautman whether it is ok to do filtered samples for UCMR3 microbial monitoring.

**Status:**

A. Miguel held a call with all of the States on May 6 on potential integration.

B. The following notes pertain to the sampling that might be done by the state along with the UCMR3 sampling by EPA-C's contractor. MDH comments are in blue, and Region 5 responses, based on Janet Kuefler's discussion with Chris Frebis of EPA-C, are in green.

1. **MDH clarified that the filtered samples described above would be in addition to the regular UCMR3 sampling that EPA-C's specially trained contract staff are doing. MDH will collect some additional samples at the same time the UCMR samples are collected for chloride, bromide, ammonia, total coliform (including high volume sample if sampling capsules are available), etc. There are some concerns about running wells dry during sampling, and EPA asks for UCMR monitoring to take precedence over state monitoring. (For just the virus monitoring, they estimate between 475 and 950 gallons, the latter for a matrix spike.)**

2. MDH wanted to confirm whether UCMR3 was a methods development or occurrence study, and also get a better understanding of how well sites were selected. UCMR is an occurrence study and is not related to method development. If there is no final published method, the method will not be included in UCMR monitoring. (I believe that if there is enough occurrence based on UCMR results, then more resources will be put into method development.) Also, ORD does not have anything to do w/ UCMR, except that they may develop methods which eventually get used in UCMR.

OGWDW develops & implements UCMR. (I forgot that OGWDW has staff in Cincy (EPA-C), and they are separate from ORD.)

3. And, if well vulnerability or sensitivity were part of that decision making process, MDH wants to compare our source risk assessment to that of EPA-C. Vulnerability was part of well selection. The Target & Analysis Branch (TAB) provided a list of eligible PWSs for selection. Vulnerability had to do w/ the well being located in karst or fractured bedrock & the well not using disinfectant. We are not exactly sure how TAB did that, but know they used lat./long. data as well as disinfectant used in SDWIS-Fed to determine this. There was no risk assessment as part of the selection process (just the inherent vulnerability of karst/fractured bedrock). The State was given the opportunity to review (& make changes to) the list of selected PWSs (& their potential replacements) in the State Monitoring Plan process. (It sounds like we might need to talk with the TAB if we want more information on this; please let us know if that is the case and we will locate the appropriate contact.)

4. MDH also requested copies of the training instructions for the sample collection procedures. Derek Losh is the Project Officer on the GLEC contract & Sandhya Parshionikar is the WAM for the virus work. We are not aware of any training video (unless GLEC has developed one internally for their samplers). However, we believe there is an SOP for the method & sampling efforts. Sandhya would be the person to contact for that.

III. <u>File Review NCWS action items</u> for discussion on including in FY14 ARDP:

A. Continue to ensure that labs and delegated programs have complete and timely data reporting, so MDH can report on time to SDWIS. (p.6 &9. recommendations.) ***Discussion:*** Jerry commented that 3 local programs conduct their own nitrate analyses, the rest go through the state lab (this is also discussed in the file review report). **Action item:** Janet will include in ARDP.

B. Ensure capability to report Stage 2, LT2 and GWR violations in 2013 (p. 11, 22 (GWR M/R)). NOTE: This is already in the FY13 ARDP, if completed on time it will not need to be included in FY14. *Discussion:* Jerry said that there have been significant deficiencies found, but they have all been corrected within 6 mos., so are not violations. **Action Item:** Jerry will check on the status of MNDWIS programming.

1. Chem/Rad: (Statements for ARDP not drafted yet.) Impact of not continuing to do quarterly monitoring after an MCL for NTNCWS/impact on ETT of using of open ended viol. for chem./rad—we had initial call on this (p. 15 footnote 3, p 21) & I will use those discussion notes to develop ARDP activities, or if additional discussion is needed, I will note that in the ARDP. ***Discussion:*** Jerry commented that ETT is not used as a tool to address issues, and that ongoing monitoring may result in systems going in and out of compliance. If monitoring stops after a violation occurs, it will alleviate that issue. Nick explained that once a system is under an order, ETT points top accruing, and that what is important is to have data to use in court, if needed. **Action Item:** Placeholder, there may be further discussion on this in the future. For the near term, Janet will include the action items Heather summarized by e-mail (from our conference call a few weeks ago with MDH managers) in the FY14 ARDP, which are:

MDH will ensure that the latest data on these violations is reported to SDWIS/FED.

If a nitrate, arsenic, radionuclides MCL violation cannot be resolved within six months, MDH will enter into a formal compliance agreement with the system and set out the monitoring schedule.

If the PWS can address the MCL violation within 6 months, there is no need for MDH to take formal enforcement action.

U.S. EPA will request updates on the systems with open-ended nitrate, arsenic, and rad MCL violations as part of the January 2013 quarterly ERP letter.

C. TCR: MDH commits to reject TCR samples over the 30 hr hold time and work with specific systems where this problem is occurring. (p. 18) **Discussion**: MDH is working with systems that have been having hold times in the 30-48 hr range, to try to get them in <30 hrs. MDH is internally discussing by which date the lab will begin rejecting the samples that exceed the hold time. **Action item:** MDH continue discussing details internally; Janet will include in ARDP with a date TBD for initiating rejecting samples >30 hrs. old.

D. Phase 2/5: MDH commits to assign violations for failure to monitor, even if the state had told the PWS that the state would do the monitoring for the system. (p.21) *Discussion:* Assigning violations should occur on a level playing field, no matter if the state or the PWS assumes that task. MDH discussed that it is difficult to issue a violation to the system when the system did not cause the violation (for missed monitoring.) Jerry said that management mechanisms are in place to ensure that 99.9% of samples are taken on time. **Action item:** Further management-level discussion is needed in regard to the ARDP commitment for this item, at a future date.

E. Phase 2/5: MDH DWP determined that automatic scheduling by MNDWIS has caused initial and second round samples to be scheduled further apart than they should be. **Action item:** Include in ARPD: This is in the process of being corrected by IT staff and by training of compliance staff. When it is corrected samples will be collected within the periods of the SMF and will actually be more restrictive than federal requirements.(p.20, 21)

F. LCR: MDH DWP will ensure that year-round child care facilities complete monitoring in the 4-month timeframe specified by the rule, as noted in their FY13 work plan with EPA Region 5. (p. 25) *Discussion:* There were not any facilities reviewed that met this criterion, Cadmus was noting this program implementation procedure. **Action item:** This will carry-over from FY13 ARDP

G. MDH will assign SWTR violations when MORs are received late. MDH DWP will encourage water systems to turn in the reports on/before the 10th day of the following month and highlight reporting deadlines on the "Annual Monitoring Schedule" that MDH DWP provides to each CWS, starting in 2013. (p. 27) (Need to clarify if MDH is committing to assign violations.) **Action item:** Jerry with follow up with R5 regarding how to address this, and it will be specified in the ARDP.

H. SWTR (Type 41). MDH will assign a TT violation for each month that the entry point chlorine residual falls below the threshold for more than four hours. (P.27) *Discussion:* Jerry will meet with the NCWS engineer on this. **Action item:** Include in ARDP.

I. Discuss and reach agreement with R5 approaches for: Invalidation criteria (& handling rejected/replacement samples), TCR begin and end dates reporting to SDWIS; PN documentation. R5 will provide training if requested. (p. 7, C-21 TCR) *See details below.*

Background info from file review:

Invalidation:

**TCR:** When a site investigation identifies suspected contamination of the original routine TCR sample, the MDH DWP field staff should invalidate the routine sample in writing and collect a replacement sample as soon as possible. The replacement sample should be counted for compliance, even if it's collected in the following month. Region 5 comment: Invalidation in this context is defined as not counting as meeting the TCR sampling requirement. The regulations allow for such invalidation when the suspected contamination of the original TCR sample is due to domestic or a non-distribution system plumbing problem. Region 5 will follow-up with NCWS staff regarding procedures currently in place to confirm a violation prior to issuing a violation, to ensure that they are at least as stringent as the federal requirements. Sample invalidations need to be documented & replacement samples need to be taken within 2 weeks (guidance only) of invalidation. (p.17) Is it ok to include this as a recommendation in the ARDP?

**LT2:** M/R violations should be assigned when invalidated samples are not replaced. (p.27) **Action item:** Ensure that documentation of invalidations exists in State files. Janet will include this item in the FY14 ARDP.

Sampling period: Existing guidance has the begin date of a violation as being the beginning of the monitoring period. For example, a system on annual sampling would have a begin date of a TCR violation of January 1. TCR: MDH DWP sets the begin date for an MCL violation to be the date that the first set of repeat samples was collected. The begin date should be associated with the monitoring period for the routine sample. Two discrepancies were identified for this reporting problem. Region 5 comment: The Region will work with the state on appropriate reporting of begin dates for TCR violations. We realize that public notice for an acute violation cannot occur until after the repeat sample is analyzed, but we believe that because total coliform is an indicator parameter, just because the original TC+ was not EC+, that does not necessarily mean there was no EC there. In terms of abundance, coliform is there in much greater amounts than fecal coliform, which is there in greater amounts than E.Coli, so the thinking is probably that if it has been confirmed that EC was there, it may have been there at the time of the original. Also, because both a routine and repeat sample are needed in order to make a compliance determination of an acute MCL for TCR, the timeframe of both samples should be included. (p.18) *Discussion:* R5 discussed with HQ, and the reporting guidance includes this requirement. MDH does not believe that this approach will result in better health protection, and believes that it will confuse the public, for example, if a system samples in November and has a reported violation beginning in January. This approach also does not make sense when you are analyzing the time it takes from the begin date of a violation to RTC the violation (example, sample taken in November, but begin date will be January.) **Action item:** Placeholder: 5/MDH need to further discuss commitment for ARDP at a future date. Under the RTCR, will the SDWIS violation data be rejected if it is not reported for an entire monitoring period? **Status**: We do not yet have SDWIS reporting guidance for RTCR. Region 5 will keep the State informed as to any planned modifications to the criteria for accepting or rejecting data where the begin date of the TCR violation does not match the begin date of the monitoring period via FedRep.

PN: A PN violation should be assigned for any treatment technique violation, if no proof of PN exists. **Action item:** Follow up is needed on this item. During the file review/EV, the state had mentioned that they don't require PN for TT violations.

Question: Is there a need for training related to determining acute TCR MCLs—file review note: "Region 5 will follow up with the state on this procedure to ensure that it is as stringent as the federal requirements, and that if a routine sample is total and E.coli positive, and a repeat sample is total coliform positive, that the system is issued an acute MCL violation (p. 17)" Are there other training requests? **Action item**: the above will be included as part of RTCR training.